Historic Rainstorms in California

August 1997

State of California
The Resources Agency
Department of Water Resources

Pete Wilson
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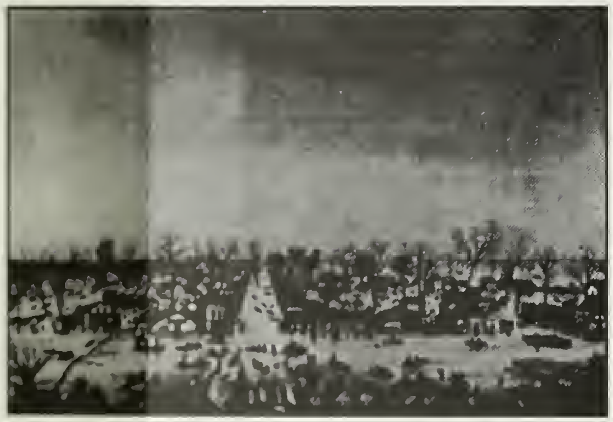

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A Study of 1,000-Year Rainfalls

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Foreword

California's weather is diverse and unpredictable, and residents have faced both droughts and floods; both of which can be disastrous. Although Californians cannot stop large flood-producing storms, they can be better prepared by analyzing flood and storm data.

This 1,000-year-storm study began as a collection of data used to analyze the adequacy of dam spillways. With the help of the United States Department of Agriculture Natural Resources Conservation Service and the California Department of Transportation, it expanded into a study of drainage and culvert design to assist decision makers regarding spillway safety and culvert sizing.

All available precipitation records were examined and the frequencies of flood-producing rainfalls were evaluated using a consistent criteria. However, the rain gage network contains "holes" where the records have not yet been analyzed, as well as missing information where gages are nonexistent.

This study explains how rainfall data is gathered and processed. It then describes each historic storm. Side bars contain detailed information on calculating return periods for the 1,000-year storms in the study.

This is also a progress report of a cooperative activity. Many county agencies have continued to contribute data for local water and drainage projects. Sharing historic data on rainfall and making data files available are important objectives of this study. Active participation of interested parties is invited in order to develop a comprehensive data base and to find better ways of organizing, analyzing, and publishing rainfall information.

Those who need to know the relative significance of historic rainfall events will find this study useful.

William J. Bennett

William J. Bennett, Chief
Division of Local Assistance

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Dedicated to all volunteer weather observers who help to make studies like this possible.

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Introduction

Storms producing record amounts of rainfall have occurred several times in the lifetime of most Californians. Following such storms, people often want to know more about the phenomena and ask questions such as: What are the greatest recorded rainfalls? What is a "once-in-a-thousand year" storm? Is there evidence of climatic variations which affect the occurrence of flood-producing rainfalls?

This study concentrates on 46 storms from the winter of 1850 to January 1993. It is based on 100,000 station years of daily rainfall observations from 3,000 rain gages. This translates to over 34 million daily rainfall observations. In statistical theory, with 1,000 rain gages there would be one 1,000-year storm each year. The reality is that California has had about 45 1,000-year storms in 90 years.

Although most of the storms studied here are 1,000-year storms, other storms with high rainfall or outstanding events have been included. A 1,000-year rainfall event is defined as having a magnitude of approximately five standard deviations above the mean at that location. The number of standard deviations is related to the skewness and variation in data of the region where the station is located. Regional design values were developed based on average coefficients of skewness, kurtosis, and variation(CV) for each region. A 1,000-year storm is not limited topographically to the windward slopes like orographic storms; they can occur anywhere.

The 1,000-year storms included in this study are listed in Table 1. (All tables appear in the Tables section, which begins on page 107.) Table 1 illustrates the storm center or the station with the rarest frequency of occurrence. Since large storms will have many stations reporting 1,000-year rainfalls, Table 2 presents a comprehensive list of *all* occurrences of 1,000-year rainfalls. For more in-depth understanding, the statistical details are included with this report.

Tropical cyclones or Mexican west coast hurricanes play an important role in the development of the great storms in California. At the south end of the Baja Peninsula, tropical storms in September and October

provide most of the annual water supply. Thirteen of the world's average of 76 tropical storms per year occur in eastern regions of the North Pacific Ocean.[1] Tropical storms included in this study are: Antioch Storm of September 12-14, 1918; Tehachapi Storm of September 28 - October 1, 1932; Brawley Storm of September 5-6, 1939; Indio Storm of September 24, 1939; Columbus Day Storm of October 11-13, 1962; Tropical Cyclone Kathleen of September 10-11, 1976; and Tropical Cyclone Doreen of August 16, 1977.

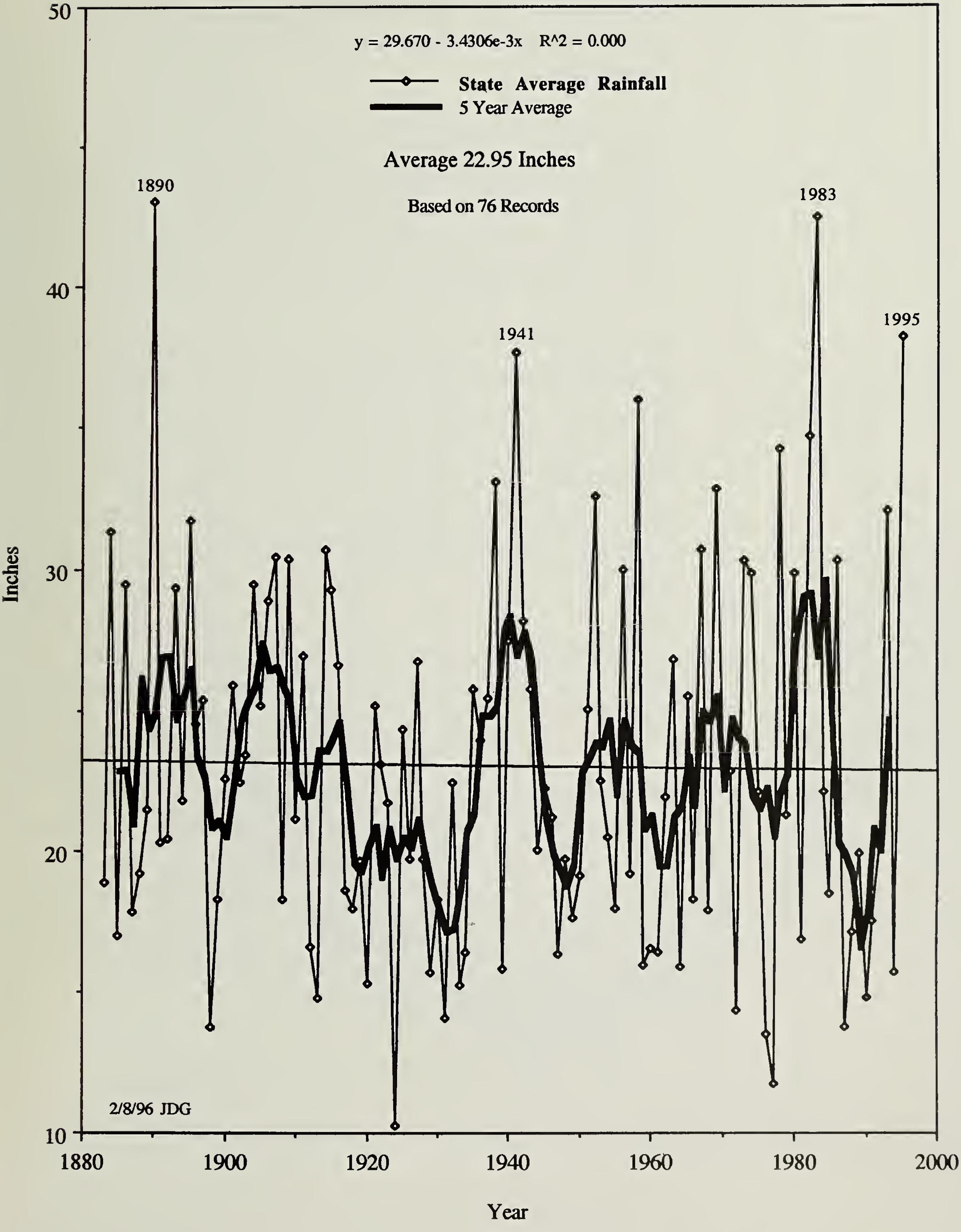
California has a remarkably variable rainfall. The average annual rainfall for the State is estimated to be 23 inches per year. However, this average is created by average annual rainfall ranging from a high of 144.3 inches at Ship Mountain in the Smith River Drainage to a low of 1.8 inches at Death Valley. The maximum yearly total rainfall for a California station was 256 inches at Camp Six in the Smith River Drainage in the 1982 water year. There are also numerous reports of stations going for a whole year without reporting rain.

Another aspect of California's rainfall distribution that affects this study is the distribution of the number of days per year when rainfall is recorded. The northern part of the State has many more rainy days per year than locations in the south, even though average annual rainfall may be similar. Probably the most remarkable statistic about rainfall in California is that the variability of the last 50 years is far greater than the previous 50 years. In general, long-term trends in rainfall extremes, as well as trends in total yearly rainfall, show drier coastal weather and wetter inland weather.

In the last 111 years, three years (1890, 1941, and 1983) were particularly wet. The 1983 water year was unique in that heavy rainfalls extended across the full length of the State. In 1890, the heavy rainfalls were confined to the north half of the State. In 1941, by contrast, the heavy rainfalls were confined to the floor of the Sacramento Valley and the coastal region of Southern California. These years are plotted on Figure 1.

Lines of equal return period do not necessarily correspond with lines of equal rainfall depth. This is partially because of the characteristic

California Rainfall Trend 1883-1995 Figure 1



buildup of robust storms on the windward wet slopes, which occasionally spill over onto the dry "rain shadow" on the leeward side of the mountains. Also, the largest storms, in terms of return period, cover limited regions.

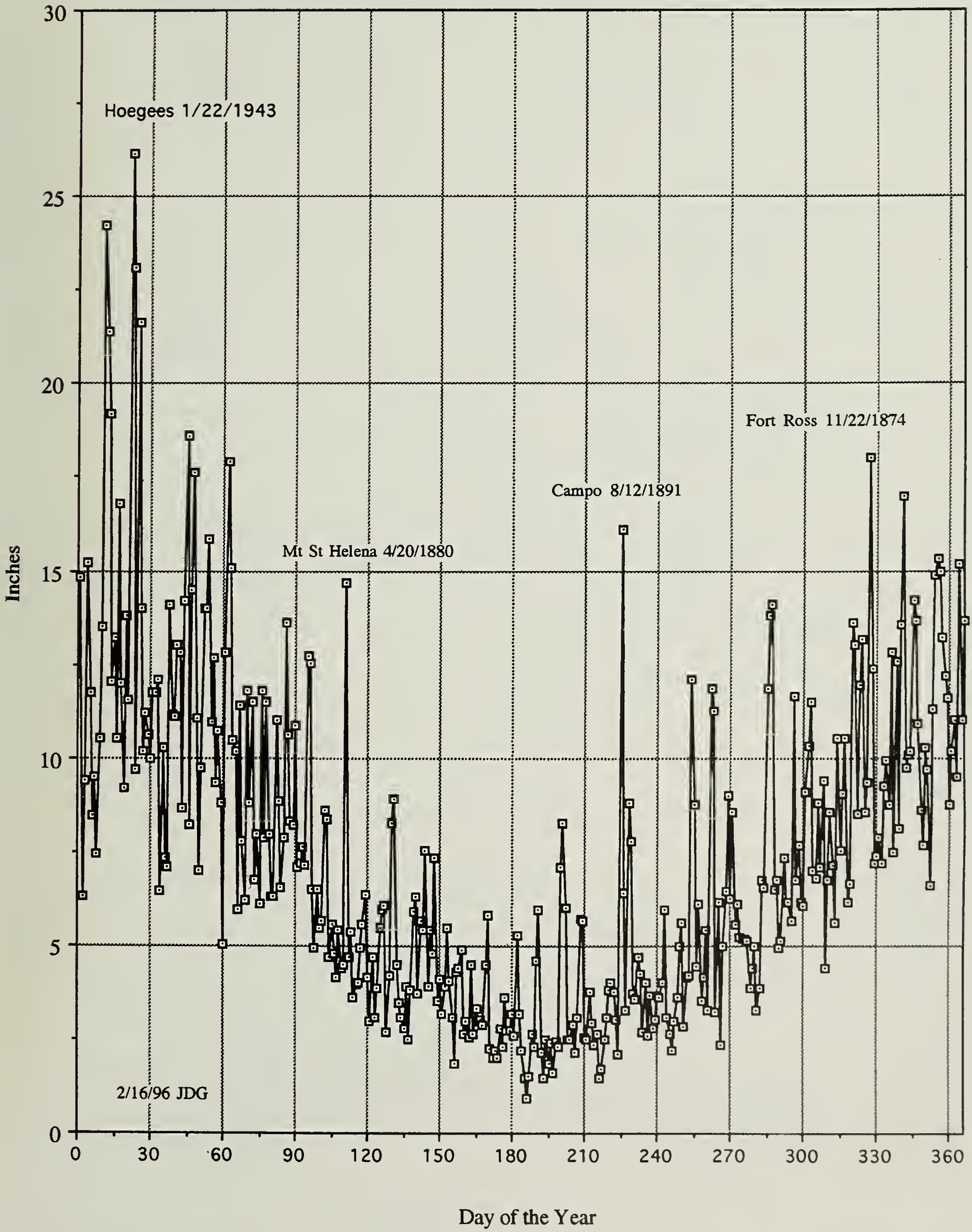
Return period is the average time in years between occurrences of storms of a given magnitude. Any serious study of rainfall frequencies should be based on more than the 95,000 station years of observation that are represented here. Therefore, this study is a summary of progress as well as an accounting for the procedures that have been used.

The most extreme daily rainfall reported in California is 9.7 standard deviations above the mean and has a return period of 360,000 years. This was at San Andreas Lake in San Mateo County on the Peninsula about 15 miles south of San Francisco. The 13.63 inches at San Andreas Lake occurred on December 19, 1871. The San Andreas Lake rain gage is one of about a dozen operated by the San Francisco City Water Department, some of which have been operated for over a hundred years.

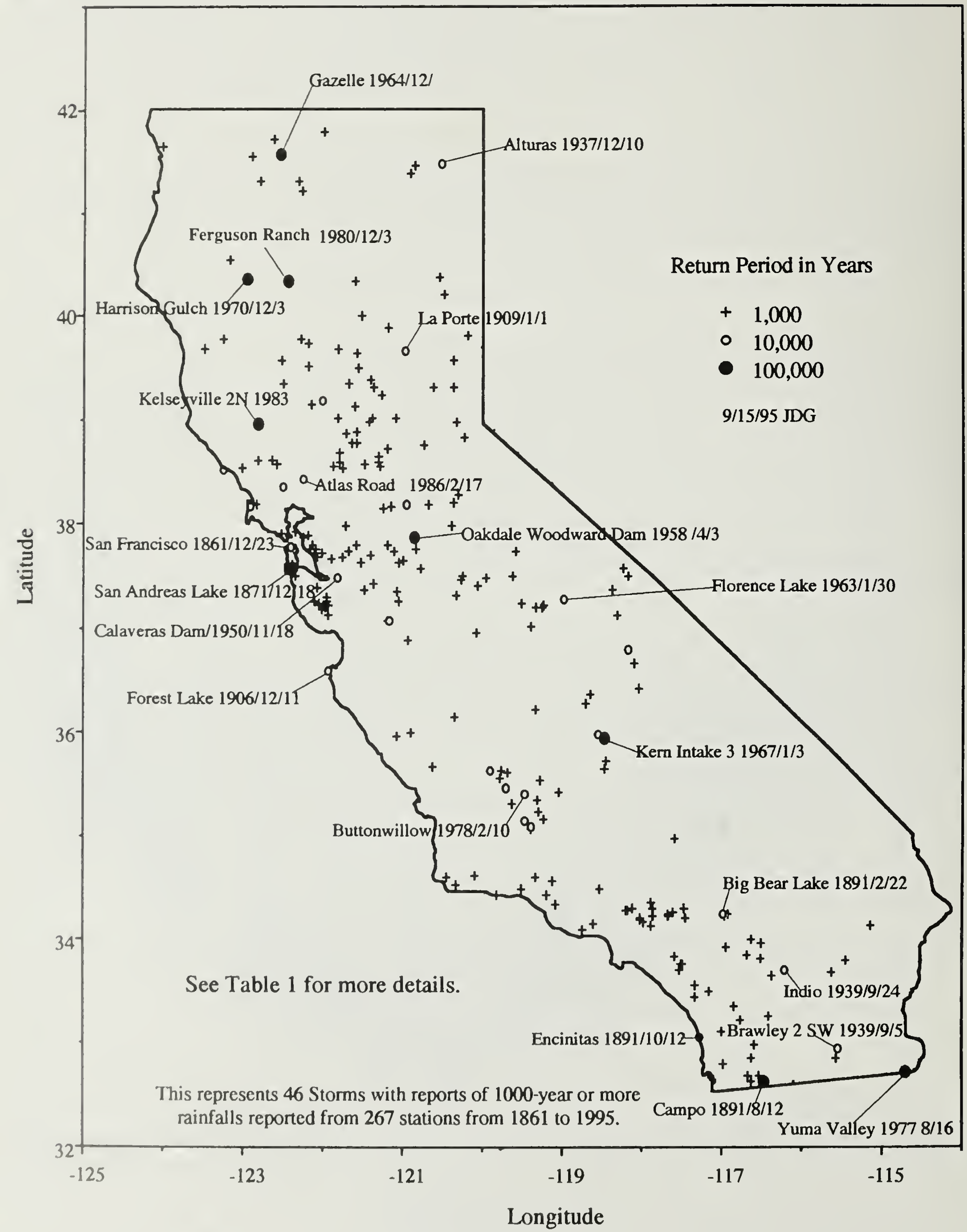
The maximum daily rainfall recorded in California, 26.12 inches, occurred on January 23, 1943, at Hoegees, located near Mount Wilson in the San Gabriel Mountains (Figure 2).

The locations and dates of occurrence of 1,000-year rainfalls for California are plotted on Map 1 on page 6. The locations of 542 10-inch(or greater)-per-day rainfalls are plotted on Map 2 on page 7. These two maps illustrate the random locations of 1,000-year storms in contrast to the uniformity in the distribution of 10-inch-per-day rainfalls in the region of orographic barriers on the windward slopes of mountain ridges, downwind from the moisture sources.

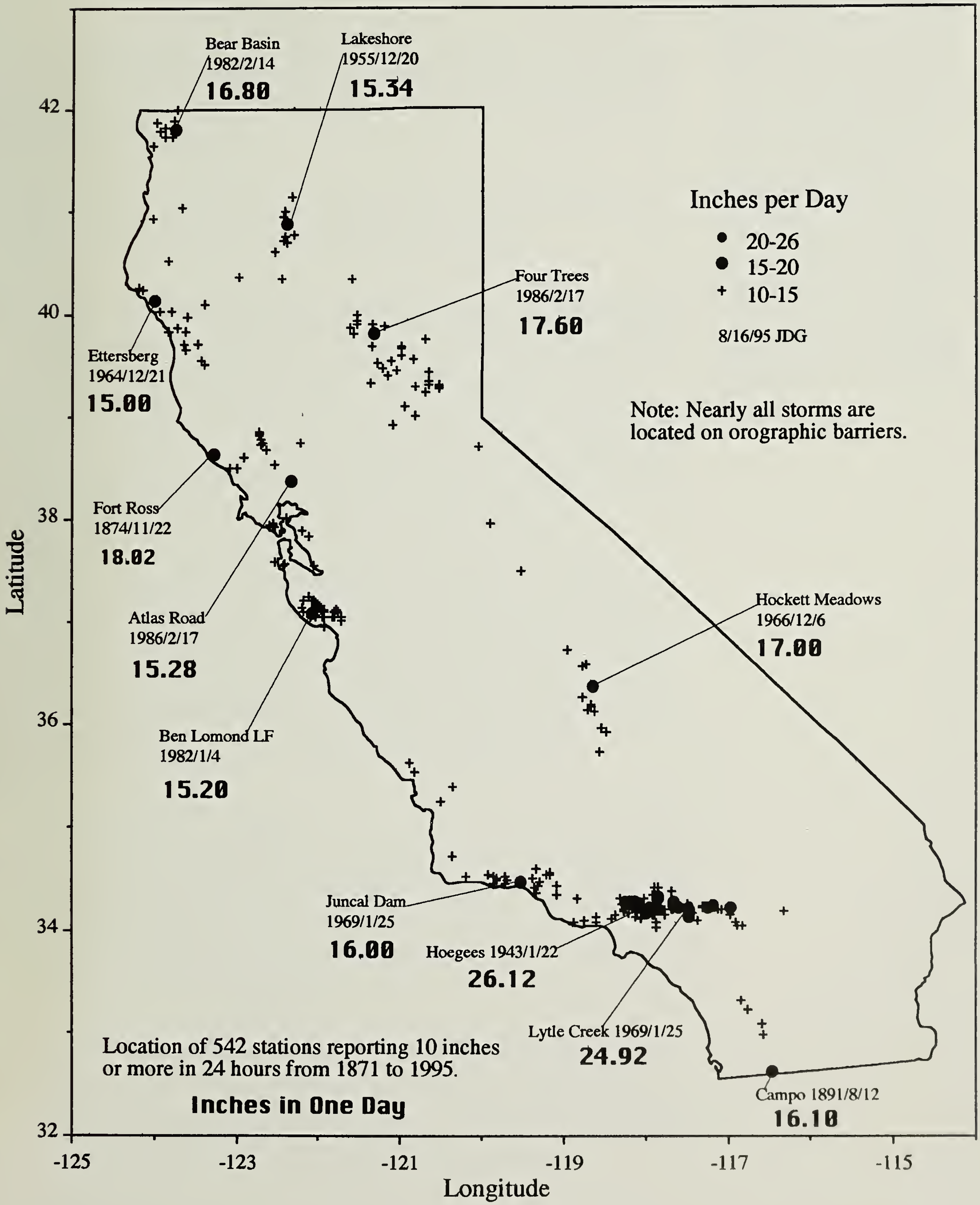
Maximum Daily Rainfall for California   Figure 2



Map 1 Locations and Years of 37 1,000-Year Storms in California



Location of 525 10-Inch(or greater) per Day Rainfalls in California Map 2



Data

The original data of this study consist of once-a-day daily rainfall measurements. Rainfall is a vertical measurement of precipitation accumulating on a horizontal surface. It consists of drizzle from fog, rain, hail, and/or melted snow.

Rainfall has been measured in California since 1850. California has more than 5,000 points where rainfall is now measured.

Data for this study were obtained from many sources, including *Climatological Data for California.*[2,3] Additional records were from the California Department of Water Resources, power companies, and flood control and water districts who rely heavily on volunteer weather observers. The National Weather Service records in *Climatological Data for California* are fairly complete for the period 1949 to present. Much of the older records still need to be added to the data base.

There may be better methods to measure rainfall than the original daily manual method, such as from the ALERT telemetered gages. However, many operators of automated data collection networks keep the records only as long as they are needed for flood forecasting. A uniform procedure for collection, publication, and archiving data is needed to provide design data in remote areas currently without rainfall records.

Limitations of Rain Gages

No rain records are perfect. Users of rainfall records are cautioned about the inherent and unavoidable shortcomings of records from rain gages. Rodda states that "Rain gages, as usually installed, regularly under-register the quantity of rain...measurements are necessarily relative and they are at best precise rather than accurate."[4]

Rain gages are, at best, an index of the actual rainfalls. Water balance studies demand the best possible estimates of actual rainfall. These studies of rainfall extremes are further limited in that the rain gages may not be sited where the maximum rainfall actually occurs.

Possible gage errors are incorrect gage geometry, aerodynamic prob-

Practical Uses for Data

Engineers use estimates of rainfall depth for given duration frequencies and return periods to determine the size of drainage facilities, bridges, and dams. California has about 1,400 dams where many of the 5,000 points of extreme annual rainfall are used to evaluate the hydraulic safety of spillways. Runoff volumes can approach rainfall rates near the end of large storms, when the ground approaches saturation, making the long duration rainfall rates a valuable tool in planning drainage facilities. Rainfall data are used in hydraulic structure design in California, because runoff records are generally not available and design storms based on rainfall are quite uniform.

lems, overcapping with snow, gage leaks, surface tension effects on measuring sticks, water lost in wetting rain gage funnels, and evaporation from the measuring tube. Errors observers make include being untrained in the decimal system, recording what is perceived to be expected regardless of the weather, forgetting to make an observation, recording at irregular observation times, and estimating observations. In editing data, there can be key entry errors and incorrect interpretations by editors.

The National Weather Service recording gages register 2.5 to 6 percent less precipitation than do their nonrecording gages.[5,6,7] Studies of the Illinois State Water Survey indicate that precipitation gages as a whole generally undermeasure because of instrumentation limitations and aerodynamic problems.[5]

Snow and wind are frequently the cause of interruptions in rainfall records. About 10 percent of the recording rain gages reported by the National Weather Service in its monthly publication, *Hourly Precipitation Data,* show a 10 percent loss of record in midwinter, whereas it shows only a 2 percent midsummer loss.[8] A problem with the *Hourly Precipitation Data* publication is that the people who collect and publish the data are not data users. The data do not have adequate quality control to generate the needed complete data set.

Furthermore, gage observers may often be unaware of a loss of record due to gages overcapping with snow or other factors associated with freezing temperatures. Gages at sites that receive heavy snowfall frequently overcap with snow, preventing them from functioning. Snow also greatly reduces estimates of precipitation intensity by adhering to the sides of gages, thus delaying the operation of the weighing mechanism until the snow melts. The loss of record due to snow can be overcome by attaching heating devices to gages subject to snow and other costly measures.

Wind causes rain gages to under register. The aerodynamic effects of the interception of wind-driven rain by rain gages have been studied for many years. In 1934, it was reported that wind blowing at 24 miles per hour on an unprotected gage at ground level will reduce the catch to

only 50 percent of the catch without wind.[9] The dynamics of these errors are quite simple. Wind around a rain gage causes an upward component of wind on the leading or windward edge of the gage. This upward component causes rain drops or snowflakes to be deflected out of the gage so that the gage under measures during windy episodes.

Ideally, adequate quality assurance/quality control measures should be taken by the data user. Using data from multiple data sites is recommended.

Accuracy of Data Records

In the course of study, the accuracy of some data must be questioned. In general, the observer is always considered correct. However, in conducting research for this study, at least three incidents did not logically match other records.

In the records for LaPorte, the observer reported 12 inches of precipitation on May 18, 1911.[2] This was not reflected in the record of snow depth, which increased only 1 inch. The observer may not have understood the decimal system and may have actually had .12 inches. If there had been 12 inches of precipitation, the storm would have been warm and would have washed away the 18 inches of accumulated snowfall. Twelve inches of rain in one day is an important factor in local decision making, such as whether or not to use flash boards in spillways during the late spring. If the 12-inch-per-day report is correct, use of flash boards may be an unsafe practice during the month of May. On the other hand, if the 8.25 inches reported for Kennett on May 9, 1915, is the greatest recorded rainfall for California in the month of May (Table 6), then flash boards might be a less dangerous practice.

Another historic weather report which needs review is the 11.5 inches in 80 minutes at Campo on August 12, 1891. The foundation was washed from under the gage, which was found to be leaning at a sharp angle during the storm. The record of this gage may not be an accurate indication of actual rainfall. If the gage was tipped into the storm, it could have been a gross over measurement. If the gage was tipped away from the wind, it would have been a gross under measurement. No doubt the rainfall was very large, regardless of the gage's reading.[10]

At Marysville on December 25, 1983, the published value of 7.29 inches appears to be 5 inches too high.[2] The record at nearby Yuba City was 2.31 inches, and many other stations in the area reported about 2 to 3 inches. If, when records are available, nearby stations recorded less than 3 inches on December 25, 1983, then the assumption can be made that 2.29 was misread as 7.29 at Marysville.

Ship Mountain in the Smith River Basin is an example of what could happen in the case of an unattended rain gage. It appears to be a record without weekend measurements. Ship Mountain has too many 1,000-year events and large daily rainfalls to be believeable; therefore, overcapping seems to have occurred frequently in the winter. With a mean annual precipitation of about 150 inches per year, this location is the wettest in California. It is in a watershed with an average annual runoff of 100 inches per year, which indicates the mean annual precipitation is reasonable.

The following is a brief description of the 1,000-year storms in California. Storms described in this report are generally not single-station storms, but those confirmed by adjacent stations. At times, however, the storms are so localized that they are not measured in more than one rain gage. The storms that have not been described in this report usually have only one station reporting a 1,000-year rainfall.

Extreme Rainfall Data

The Maximum Daily Rainfall by Month in California is listed on Table 6 for each month and each of the 13 major geographic areas shown on Map 3. Map 3 also shows the hydrographic units which are part of the station number used on Tables 1 and 2 and are used on all of the 2,800 rainfall records summarized in this study.

The State's 15-inch-per-day rainfalls are listed on Table 7.


DRAINAGE PROVINCE
A SACRAMENTO RIVER
B SAN JOAQUIN RIVER
C TULARE LAKE
D-T CENTRAL COASTAL
E SAN FRANCISCO BAY
F NORTH COASTAL
G NORTH LAHONTAN
W SOUTH LAHONTAN
X COLORADO RIVER
Z SAN DIEGO
Y SANTA ANA
U LOS ANGELES
DRAINAGE PROVINCE BOUNDARY
B20 HYDROGRAPHIC UNIT
PACIFIC
OCEAN
N

Analyzing Data

The Annual Series (see Glossary, page 87) used here is for easy file maintenance.

The actual data series is included for data users who may wish to develop alternate procedures or select a different frequency distribution. An analysis is developed for this writer's use in mapping historic storms and for potential users' convenience, but end users are responsible for choosing this or their own applications and data analysis.

This study uses mainly nonrecording rain gage records and daily totals only from recording rain gages. Annual series rainfall totals for 1, 2, 3, 4, 5, 6, 8, 10, 15, 20, 30, and 60 consecutive days were selected. The United States Weather Bureau has tabulated extreme data for storm durations of 5, 10, 15, and 30 minutes and 1, 2, 3, 6, 12, and 24 hours.[11] This storm report addresses the need of long-duration storm data for 1-60 days so that it includes antecedent rainfall.

At most weather stations, precipitation is measured once a day. However, engineering applications generally require measurements of maximum rainfall for 1,440 consecutive minutes without regard to the fixed observation times of individual observers, using nonrecording rain gages. The maximum 1,440-minute rainfall averages have been found to be 114 percent of the once-a-day observations.[12]

Regional Analysis

There are many ways to analyze rainfall records, but there is not a lot of difference between commonly used methods. This study uses a regional approach to analyzing rain records in order to reduce the variation of short rain records, which are greatly influenced by outliers. The most important part of a regional rainfall analysis is a good estimate of the regional values of the coefficient-of-variation used to develop an estimate of the design standard deviation. Design rainfalls for a regional study are far more sensitive to the design value of the standard deviation than the choice of frequency distribution or choice of partial or annual series.

Precipitation Analyses Publications

Many of the precipitation analyses used here were published in Department of Water Resources' Bulletin 195, *Rainfall Analysis for Drainage Design, Volume II.*[12] The three volumes of Bulletin 195 are:

- Volume I: *Short-Duration Precipitation Frequency Data*
- Volume II: *Long-Duration Precipitation Frequency Data*
- Volume II: *Intensity-Duration-Frequency Curves.*

These were updated in 1981.[14]

The annual variations in rainfall frequencies were examined in an October 1980 DWR report, *Maximum Daily Precipitation by Months.*[15] That report contains an extensive microfiche file of extreme daily rainfall by months and an associated frequency analysis.

The data sets for the 1994 update are available to all on a data-sharing basis. The records are in Macintosh Excel 5 spreadsheets and will fit on two 44 MB Bernoulli drive disks. These records are available from Bill Mork or Matt Winston at the Office of the State Climatologist.

The regional analysis consists of expressing rainfall frequency as a series of parameters, then averaging the parameters by regions of climatic similarity. The parameters averaged are the coefficients of variation, skew, and kurtosis. The averages were weighted by length of record. This is done to select a frequency distribution and regional design value of the coefficients of skew and variation.

The total annual rainfall is analyzed for each series so that the mean annual precipitation can be used for interpolation between stations. A common base period is not used. This would require a reduction of the total amount of records available. Common record length was used for the studies of climatic variation section of this study, however.

To simplify file maintenance, an easily updated annual series is used in analyzing rainfall extremes. The annual series refers to the series of the largest rainfalls of each year, as opposed to the analysis of the largest rainfalls of record. This greatly simplifies file maintenance since one new value is added to the data base each year, making it unnecessary to maintain an active file of the entire record at each station. The rainfall depth-duration frequency tables on which this work is based are being continually updated, and it is expedient to keep it simple. The annual total rainfall is analyzed for each series so that the mean annual precipitation can be used to interpolate between stations. Another simplifying concept is use of the generalized formula for hydrologic frequency analysis using frequency factors (equation 1 or 2).[13, 14]

The regional coefficients of variation are listed on Table 3. The geographic variation in the coefficients of skewness for extreme rainfalls is listed on Table 8.

Frequency Distribution

Several frequency distributions were examined in previous studies. The Pearson Type III distribution was selected as the appropriate one for extreme rainfall based on the skew-kurtosis map described by Wu (1974) and Elderton (1969). There have been more recent suggestions for other frequency distributions from Melvin Schafer of the Washington State Dam Safety Office and Jim Wallis of IBM Research Division in Youngstown, New York.[15,16,17]

In prior studies, the Pearson Type III distribution was determined to be appropriate for the analysis of rainfall extremes.[18,19] The selection of this distribution is based on a relationship between the coefficients of skew and kurtosis as developed by Karl Pearson early in the century.[20] The frequency factors for this distribution are listed here as Table 4.

The return periods of this study were calculated using procedures "frozen" in time in the early 1980s. This was done so that all of the rain records could be analyzed by a common method in order to accommodate the interstation comparisons of storms.

A data set of the size of this study should reside in a separate data base containing all of the extreme annual rain records. A separate analysis procedure which can be easily modified is needed to analyze the data. This study is based on 3,000 separate Excel spread sheets. This change was made when a main frame computer was unavailable and the data sets needed to be moved to a desktop computer for file maintenance. Moving these data sets back to a data base will be a major effort and is beyond the scope of this study.

The frequency factors (K) of the Pearson Type III distribution as used here are from Harter (1968). They are shown in Table 1. As an example of the significance of skewness in hydrologic frequency and analyses, a thousand-year storm is defined as mean plus 3.67 standard deviations with a skewness of 0.4, and the mean plus 5.91 standard deviations with a skewness of 2.0. The frequency factor (K) is the only part of equation 1 containing a reference to frequency of occurrence.

The selection of fixed return periods used in this analysis is based on the values of Pearson Type III distribution supplied by the USDA Soil Conservation Service.[20] A value for a 500-year return period was added, however, in order to have a value that is closer to the United States Army Corps of Engineers' "standard project flood."

Regional Smoothing

Wide ranges in calculated design storms are due to the effects of outliers in the data sets and a low number of recorded years. The

Pearson Type III Distribution

Pearson Type III distribution was selected as the appropriate frequency distribution for extreme rainfall based on the skew-kurtosis map.[18,19,20]

The frequency factor (K) is the only part of the equation containing a reference to frequency of occurence.[13]

The frequency factors (K) of the distribution used here are shown in Table 4.[21] As an example of the significance of skewness in hydrologic frequency analyses, thousand-year storms are defined as "the mean plus 3.67 standard deviations with a skewness of 0.4," and "the mean plus 5.91 standard deviations with a skewness of 2.0."

The general equation for hydrologic frequency analysis is:[14]

(1.) $P_{ji} = \overline{P}_i + K_j s_i$

Where:

j= return period in years

i= specific storm duration in minutes, hours, or days

P_{ji}= precipitation in inches for return period j and duration i

$\overline{P}_i$= average maximum annual storm for duration i

K_j= frequency factor (in standard deviations in excess of the mean) for a return period of j years (table 4)

s_i= standard deviation of maximum annual rain for duration i

When both sides of equation are divided by s_i the equation takes the following form:[14]

(2.) $P_{ji} = \overline{P}_i(1 + CV_i \times K_j)$

(3.) $CV = s / \overline{P}$ = coefficient of variation

Statistical Estimators

Estimators used in rainfall analysis are:

- Mean = $\overline{P}$
- Standard deviation = s
- Coefficient of skew = g
- Coefficient of kurtosis = k

The equations of these estimators are:

Where:

- $\overline{P}$ = average precipitation
- P = annual extreme rainfall
- n = number years of data

4. $\overline{P} = \sum P / n$
5. $s2 = (\sum P^2 - (\sum P)^2/ n) / (n-1)$
6. $g = (n^2\sum P^3 - 3n\sum P\sum P^2 + 2(\sum P)^3) / n(n-1)(n-2)(n-2)s^3$
7. $k = (n^3\sum P^4 - 4n^2\sum P^3\sum P + 6n\sum P^2(\sum P)^2 - 3(\sum P)^4 / n(n-1)(n-2)(n-3)s^4$

The design rainfall is the product of the average storm times one plus the product of the regional coefficient of variation (equation 2) and the appropriate frequency factor, all multiplied by the appropriate fixed interval correction. The Fixed Interval Correction (FIC) shown on Table 5 refers to the ratio of the average maximum rainfall from fixed interval observations compared to the actual maximum values.[12]

smoothing procedure is intended to incorporate the outliers in the data and to develop design storm estimates that could be duplicated.

Previous studies show regional similarities in two important parameters: the coefficients of variation (CV) and skewness (g).[19] The coefficients of variation and skew were averaged for 13 regions of California (Map 3 on page 13) and are listed on Tables 3 and 8.[19,22] The design values of the coefficients of variation and skew were averages weighted by the length of record. These regional averages need to be updated in the future.

A project for future refinement of these studies is to develop contour maps of skew and variation in order to overcome the problem of discontinuity at the boundary between the mountains and deserts. The region on the eastern slopes of the Cascades, the Sierras, and the Coast Ranges are truly the "problem climate" of the State and need a denser rain gage network.

Maps of lines of equal return periods can be drawn because rainfall records for this study were reduced to dimensionless coefficients. Those coefficients have been averaged over climatically similar regions to reduce variation due to small sample size. These averaged coefficients are used to reconstruct the rainfall depth duration frequency tables on which these maps are based.

Fixed Interval Corrections

In 1964, a theoretical derivation of the ratio of true to fixed-interval-correction (FIC) maximum precipitation based on a probability model was published.[11] The ratio applies only to the averages of extreme storms, rather than to individual yearly data. Values of FIC are given below for various numbers of consecutive hours.

Hours	1	3	6	12	24
FIC	1.14	1.044	1.022	1.011	1.005

These ratios are independent of the time interval and are equally valid when used to describe hourly, daily, or monthly extreme values.

The values of FIC for daily values were adapted from Weiss as follows:

Days	FIC
1	1.14
2	1.07
3	1.04
4	1.04
5	1.03
6	1.02
8	1.02
10	1.01

The same concept can be applied to any discrete fixed beginning and ending time interval, whether it is in minutes, hours, days, or months.

Design Rainfall

Design rainfall is the product of the average storm times one plus the product of the regional coefficient of variation (equation 2) and the appropriate frequency factor, all multiplied by the appropriate fixed interval correction.

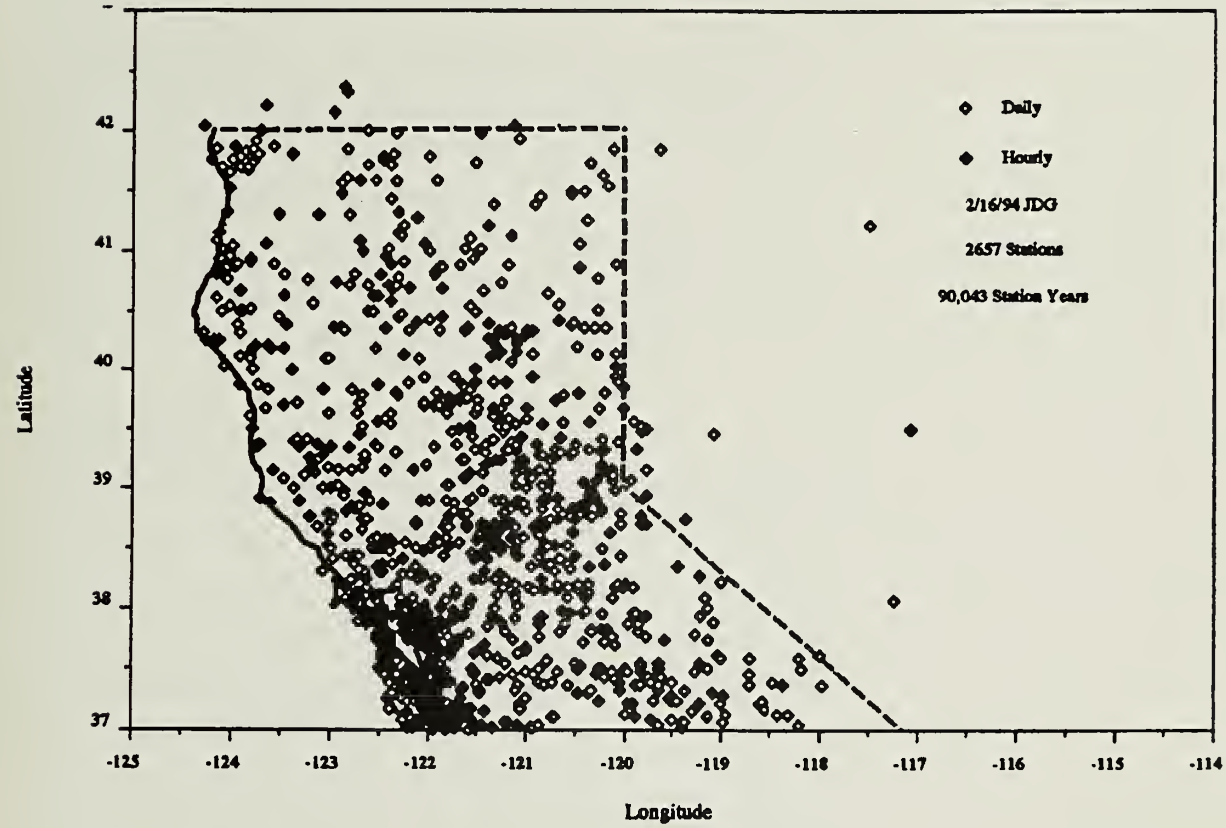
Design storms are estimates of precipitation depths for design return periods. Design storms based on streamflow records reflect greater annual variation in streamflow when compared to rainfall records. Storm durations for design storms usually correspond to the concentration time. The total antecedent rainfall is frequently the guiding concept in design storms because runoff coefficients can approach unity near the end of large storms, when the ground becomes saturated. For this reason, the long duration rainfall rates are a valuable tool in planning drainage facilities.

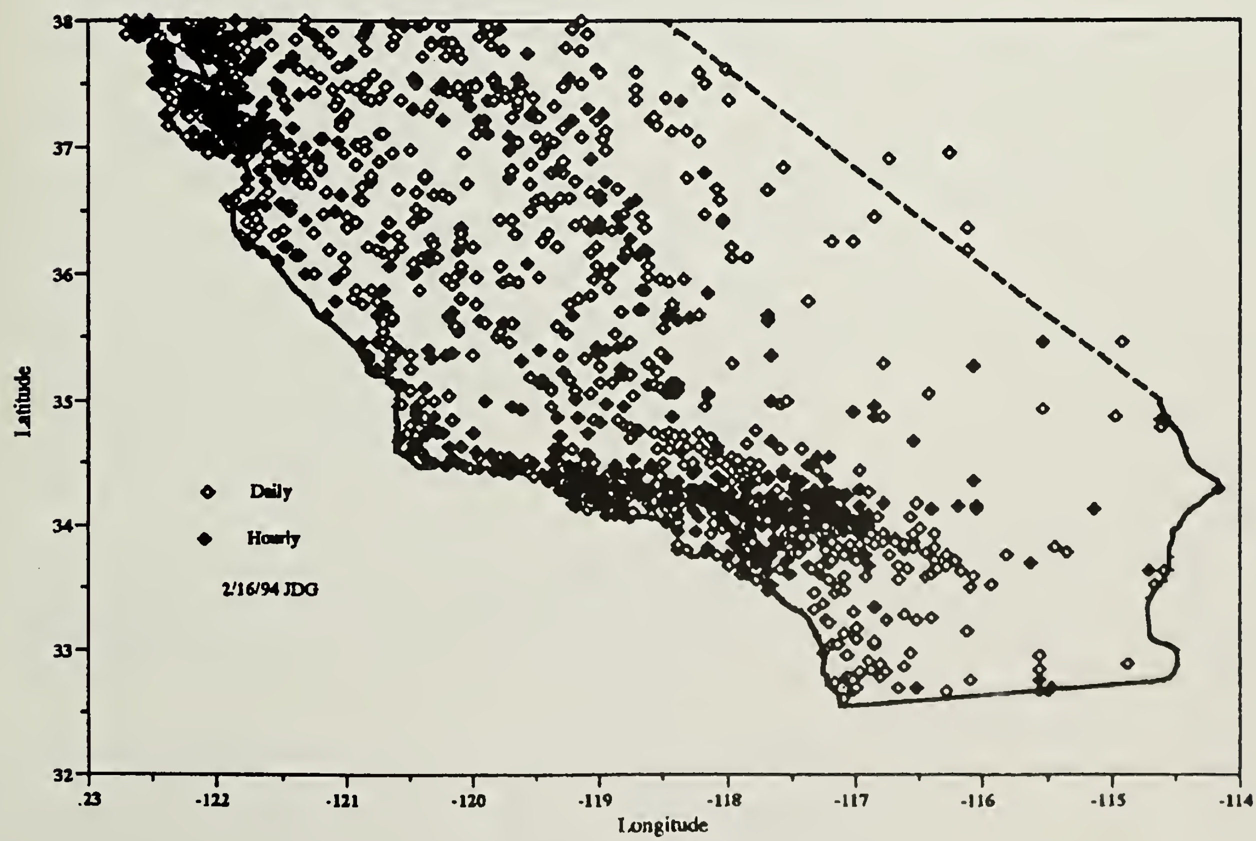
Rainfall Depth-Duration Frequency Tables

Design rainfall values for storm durations from 5 minutes to 60 days have been developed for about 900 recording and 1,900 nonrecording gages in *Rainfall Depth Duration Frequency for California*.[22] These tables are being updated and supplemented. Since 1983, data have been developed on over 3,000 stations with 100,000 station years of data.

An example of rainfall depth-duration frequency tables are shown as a rainfall study for Arcade-Greiner (Table 5). This table consists of four parts. At the top of the table are data on station location and origin of the record. Next is the annual extreme values for each year of record. The next group show statistical parameters describing the previous data set. The last group consists of the estimates of the rainfalls for various return periods from 2 to 10,000 years for storm durations of 1 to 60 consecutive days and the water-year total.

All of the data and the analyses are available to cooperating agencies from the State Climatologist Office. These data sets are on Excel spreadsheets so that they can be easily updated. These data points are plotted on Map 4, page 21.


Daily
Hourly
2/16/94 JDG
2657 Stations
90,043 Station Years
Latitude
42
41
40
39
38
37
-125
-124
-123
-122
-121
-120
-119
-118
-117
-116
-115
-114
Longitude


Daily
Hourly
2/16/94 JDG
Latitude
38
37
36
35
34
33
32
.23
-122
-121
-120
-119
-118
-117
-116
-115
-114
Longitude

This is an overview of records of a large number of daily total rainfall measurements in California. These records were originally compiled to assist decision makers regarding spillway safety and culvert sizing. It required examining all available precipitation records and evaluating the frequency of flood-producing rainfalls for the areas affecting the projects. There are "holes" in the rain gage network where the records are not yet analyzed as well as places where gages do not exist.

Storm of Winter 1850

Storms without quantitative measurement to substantiate their existence are difficult to analyze. This Sacramento flood was described by F.D. Calhoon in a first-hand account.[23] The City was swamped by overflow from the American River. Calhoon described the horrible calls for help coming from drowning hospital patients as the floodwaters rose throughout the City. The sickest patients were the first to drown. They were unable to help themselves or climb into an upper bunk in the overcrowded hospital. McGlashan characterized the water year 1849-1850 as "one of the wettest and most floody years."[24] Sacramento had 12.5 inches of rain in December 1849; in January 1862 it had 15 inches of rain.

Storm of December 23 - January 21, 1862

The legend associated with this storm is that one could have gone from Folsom to Winters in a row boat as the Sacramento Valley was one big lake. The truth is that there were not enough records to know what happened in the watershed areas. This storm rainfall was recorded at only a few low elevation stations. The heaviest rains were at San Francisco where 28.25 inches were reported in 30 days. This was 6.48 standard deviations above the mean with a return period of 37,000 years.

A report from the Stockton Independent Record quotes Dr. Snell of Sonora reporting 30 inches at Sonora in 10 days. This would be 7.84 standard deviations above the mean and a very rare event.

An account of the 1862 flood at Snelling, on the Merced River, by the *Gazette News* reported that the hotel had broken up.[25] This disaster was "caused by a flood from the Merced River, when part of a mountain slid

into the river, temporarily damming it up and when it broke a torrent thirty feet high went down the river, carrying away Benton Mills and part of Snelling."

Storm of December 21, 1866

The maximum one-day rainfall for San Francisco was 7.76 inches. It occurred between 11:45 a.m., December 19, 1866, and 8:15 a.m., December 20, 1866. Six San Francisco area rain gages recorded very high rainfall on this day.[26] The annual average maximum rainfall for a 1,440-minute rainfall at San Francisco, based on 104 years of recording gage data, is 2.20 inches. The 7.76 inches represent 6.27 standard deviations above the mean. The corresponding return period is 6,300 years.

Pilarcitos, 15 miles south of San Francisco, recorded 9.18 inches on this day. This was the next-to-the-highest daily rainfall of its 127-year record. The highest daily rainfall at Pilarcitos was 10.79 inches in 1871.

Storm of December 18-20, 1871

San Andreas Lake, located 3 miles north of Pilarcitos and about 3 miles west of the present location of San Francisco Airport, had 13.63 inches of rain on December 19,1871. The three-day total for December 18-20, 1871 was 27.16 inches. This was 9.7 standard deviations above the mean with a return period of 330,000 years.

Pilarcitos had 20.92 inches during this period. This was 5.8 standard deviations above the mean, for a return period 3,500 years. Both of these records are part of the San Francisco Water Department rain gage network. They are among the longest rain records in California.

Storm of April 20-21, 1880

Sacramento's greatest two-day storm was 8.37 inches. This was 5.79 standard deviations above the mean with a return period of about 3,500 years. Weaver indicated that a low-pressure area came ashore west of Red Bluff and that the heaviest rainfalls were located in a west to east band extending from St. Helena to Nevada City.[26]

Storm of December 1884

The highest rainfall measurements of this storm were at Bowman Dam.

The rainfall data for six days of 33.80 inches was reported.[26] This is 4.94 standard deviations above the mean with a return period of 1,900 years.

The rain record at Bowman Dam started in 1872 but daily values before 1912 are sparse because early records were lost in the San Francisco earthquake and fire of 1906. The records were largely recompiled at the San Francisco Weather Bureau Office. However, when the Weather Service Climate Office was closed in 1973, the records were moved to Ashville, North Carolina. The records, on microfiche, have been available for weather researchers in California, but only at great cost.

Water Year 1890 (Map 5 on page 26)

The heavy rainfalls of 1890 were confined to the north half of the State. The precipitation totals for this year are compared with other years on Figure 1, page 3.

Storm of February 22-23, 1891

One of California's biggest storms occurred at Big Bear Lake Dam on February 22 and 23, 1891, when 32.20 inches were recorded in two days. This was 7.25 standard deviations above the mean for a return period of 22,000 years. This large event was confirmed by the large rainfall at Cuyamaca in San Diego County which had 22.40 inches in this storm. This storm was the biggest two-day rainfall of record at both stations.

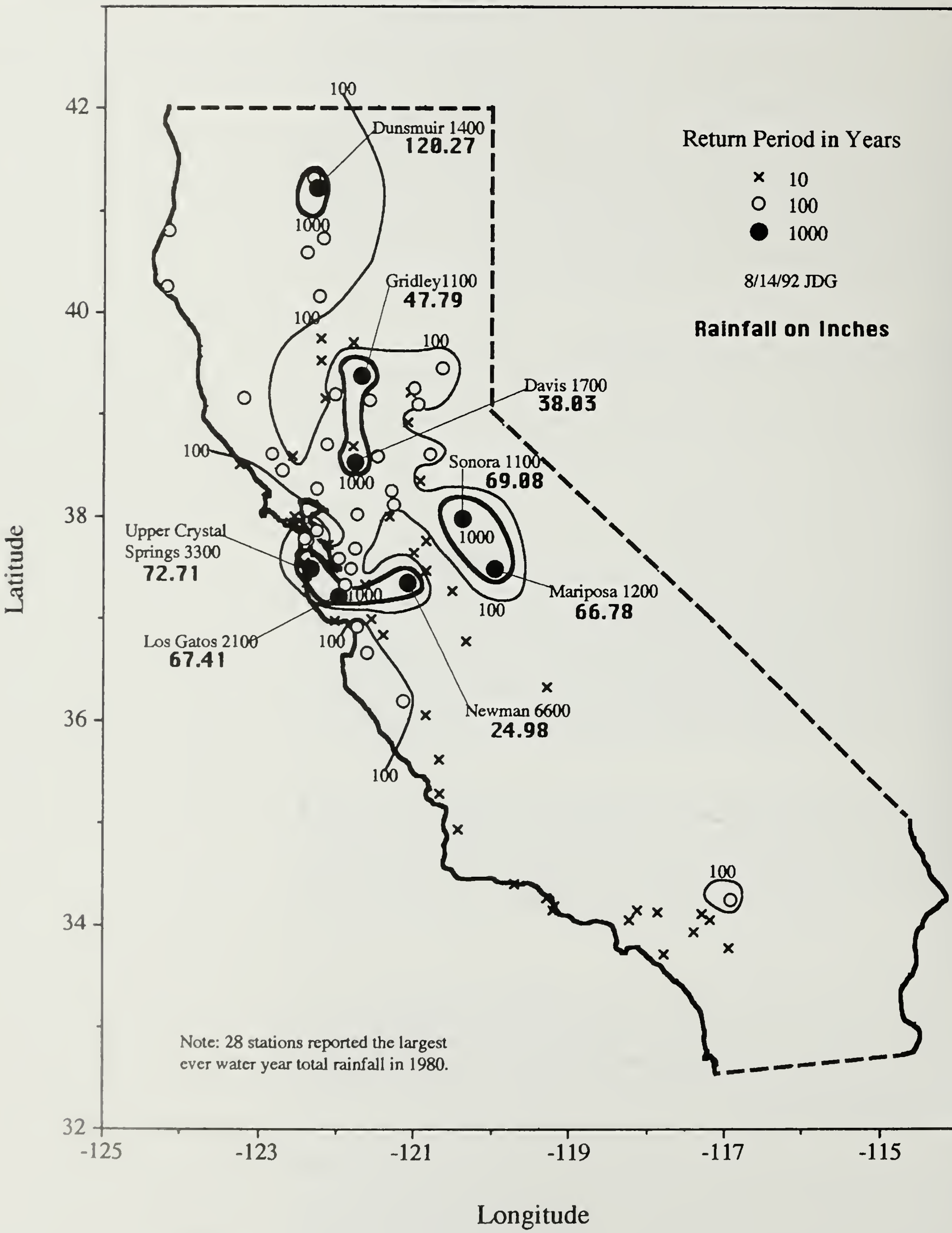
Big Bear Lake Dam is located in the San Gabriel Mountains at an elevation of 6,815 feet. Cuyamaca is on the western slope of the coastal range in San Diego County at an elevation of 4,650 feet. Nearby low elevation stations did not share the unusually heavy amounts of rain in this storm.

Storm of August 12, 1891

This storm is described as one of the most intense local storms ever reported in the United States.[10] Campo is located just north of the United States–Mexican border, southeast of San Diego in the coastal region at an elevation of 2,500 feet.

The Campo rainstorm is a puzzling event. The heaviest part of the storm started at 11:40 a.m. and was over by 1:00 p.m. The gage was measured and emptied several times during the storm as it had overflowed. Eleven

Map 5 Rainfall for Water Year 1890



and one-half inches was actually measured in 80 minutes. The foundation was washed from under the gage which was found to be leaning at a sharp angle during the storm.

The record of the Campo gage may not be an accurate indication of the actual rainfall. If the gage was tipped into the storm, it could have been a gross over measurement. If the gage were tipped away from the wind, it would have been a gross under measurement.

The observer, Mr. Gaskill of Campo, reported that the gage was washed away in the resulting flood before the end of the storm. Mr. Gaskill was said to have been a very reliable observer by the official in charge of the San Diego Weather Bureau Office at that time. The Weather Bureau's Technical Paper No. 40 discusses this storm, which has been accepted as a cornerstone in the National Weather Service's probable maximum precipitation studies for California.[10]

If the Campo storm were a 24-hour event, it would have been 10.15 standard deviations above the mean with a return period of 270,000 years. If this record is accurate, no other rainfall event for California comes close to being as big as this storm.

Storm of September 26, 1898

This storm was centered at Tulare in the flat lands of the San Joaquin Valley. It was apparently an isolated low-elevation storm. This storm occurred during the hurricane season when infusions of tropical moisture are not uncommon. This could have been a thunder storm imbedded in a tropical storm remnant. More study is needed.

The greatest rainfall at Tulare for the storm was 3.89 inches. This was 5.66 standard deviations above the mean with a return period of 2,700 years. Several other stations in the vicinity had over 3 inches of rain on this day. This was the wettest day ever at nearby Dinuba.

Storm of December 11, 1906 (Map 6 on page 29)

The storm of December 11, 1906, was centered at Forest Lake located along the famous 17-mile drive in Pacific Grove near Monterey. Nine stations reported greatest rainfalls in a narrow band extending from the southwest

to northeast direction from Monterey to Ione in the Sierra Nevada foothills.

Forest Lake had 6.07 inches which was 6.38 standard deviations above the mean for a return period of 9,000 years. Eight other stations reported the heaviest ever one-day rainfalls on this day.

Storm of January 1-20, 1909 (Map 7 on page 30)

The storm sequence of January 1-20, 1909, extended in a southwest to northeast direction from Fort Ross on the coast to Greenville in the Feather River Basin. Eight stations reported the greatest 20-day rainfall totals, from Graton in the Russian River Basin to La Porte in the Feather River Basin. LaPorte had 57.41 inches in 20 days, which is 5.38 standard deviations above the mean and represents a return period of 12,000 years.

Storm of January 9-14, 1911

The storm of January 9-14, 1911, extended in a southwest to northeast line between Los Gatos and Galt. The greatest rainfall recorded was 17.34 inches at Los Gatos with a return period of 800 years. Thirteen stations reported the greatest six-day rainfall during this storm.

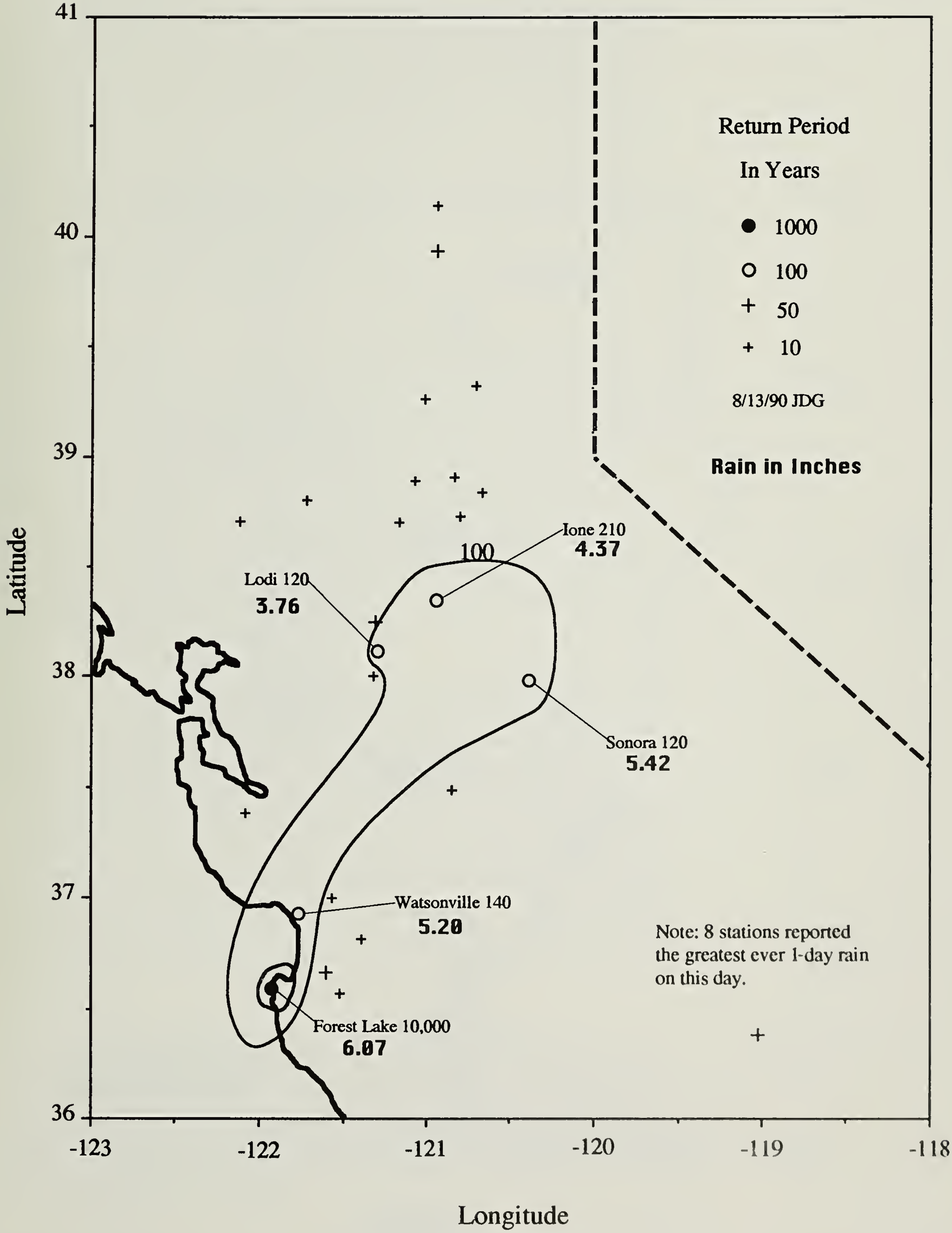
Storm of January 2, 1916

This storm was recorded at Colusa in the low elevations of the mid-Sacramento Valley. This storm is remarkable because Colusa received 36 percent of its average annual rainfall on this day. It was also the wettest day on record for Davis and Chico. Colusa had 5.60 inches of rain on this day which was 7.23 standard deviations above the mean with a return period of 42,000 years.

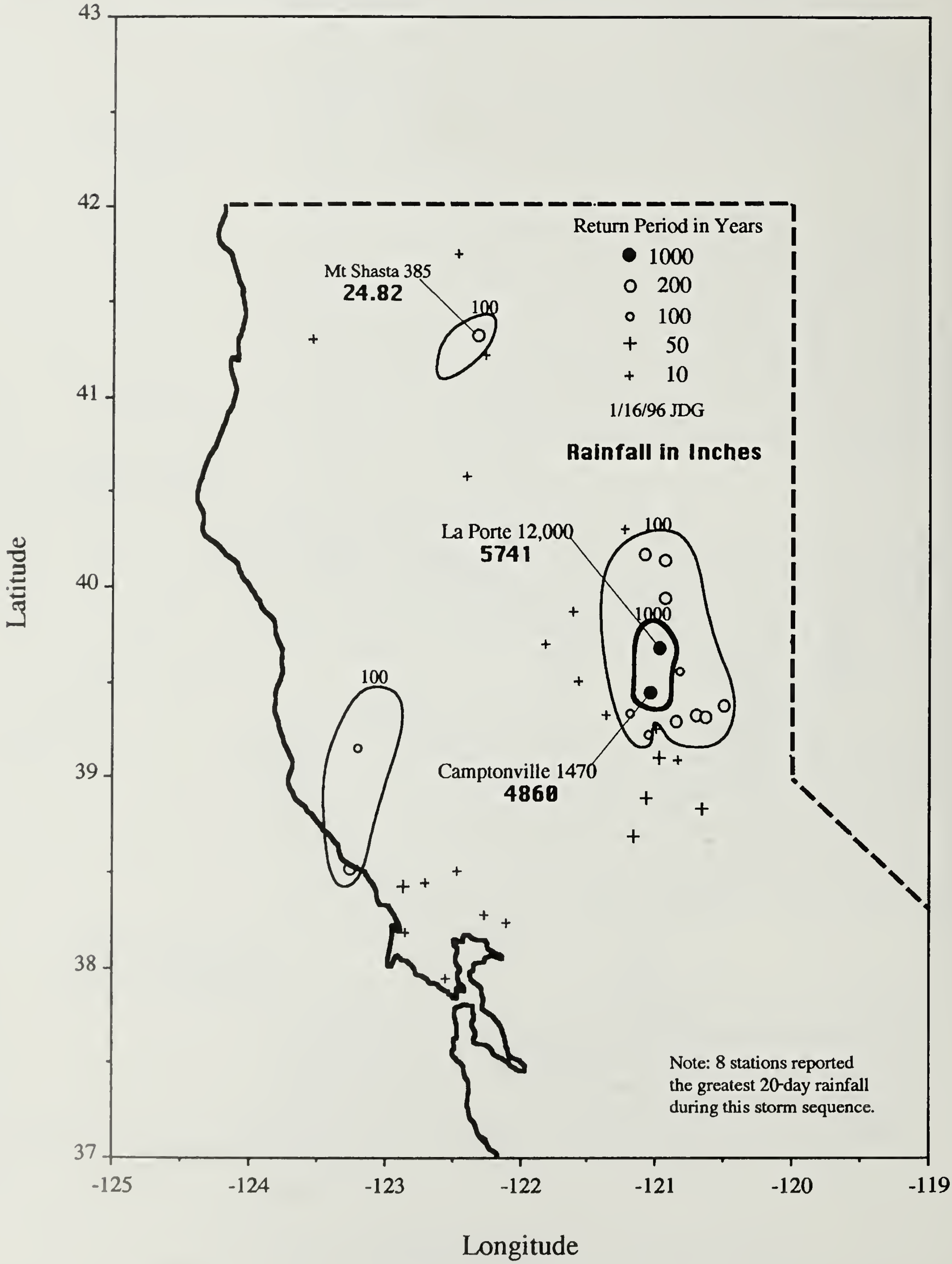
Throughout California, 1916 was a year of vigorous weather systems. In the San Joaquin Valley, a very rare snowstorm at the end of December 1915 covered the man-made forest of oil derricks between Maricopa and Kittrick. Half of these 2,300 derricks, which ranged in height from 70 to 130 feet, were destroyed in two large wind storms that occurred on January 17 and 27.[27]

Storm of January 14-28, 1916 (Map 8 on page 32)

The "mother of storms" visited San Diego County in January 1916,


41
40
39
38
37
36
Latitude
-123
-122
-121
-120
-119
-118
Longitude
Return Period
In Years
1000
100
50
10
8/13/90 JDG
Rain in Inches
100
Ione 210
4.37
Lodi 120
3.76
Sonora 120
5.42
Watsonville 140
5.20
Forest Lake 10,000
6.07
Note: 8 stations reported the greatest ever 1-day rain on this day.

Map 7 Storm of January 1-20, 1909



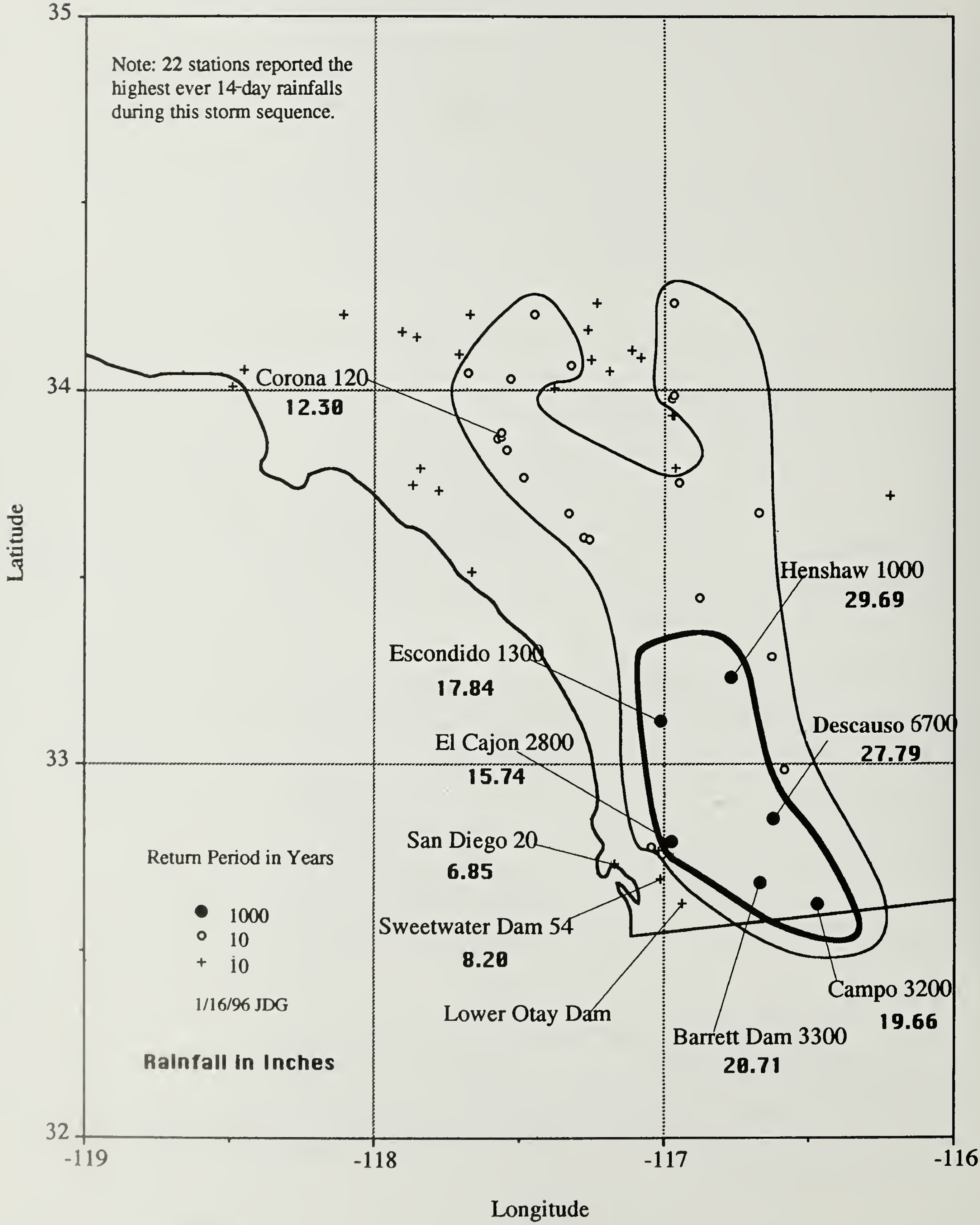
apparently invited by Charles Mallory Hatfield, a rainmaker. Mr. Hatfield began experimenting with rainmaking in 1903. His methods were proprietary, and he died in 1958 without revealing them. He met with the San Diego City Council in December 1915 and agreed to fill Morena Reservoir within one year for a fee of $10,000. By January 19, Morena Reservoir was full and rainmaking operations ceased, but the rain did not. Two dams were destroyed and 22 lives were lost, mostly downstream from Lower Otay Dam, which was completely washed away. The City Council denied payment, reportedly saying Mr. Hatfield would have to accept responsibility for $4.5 million in damages if he received payment.

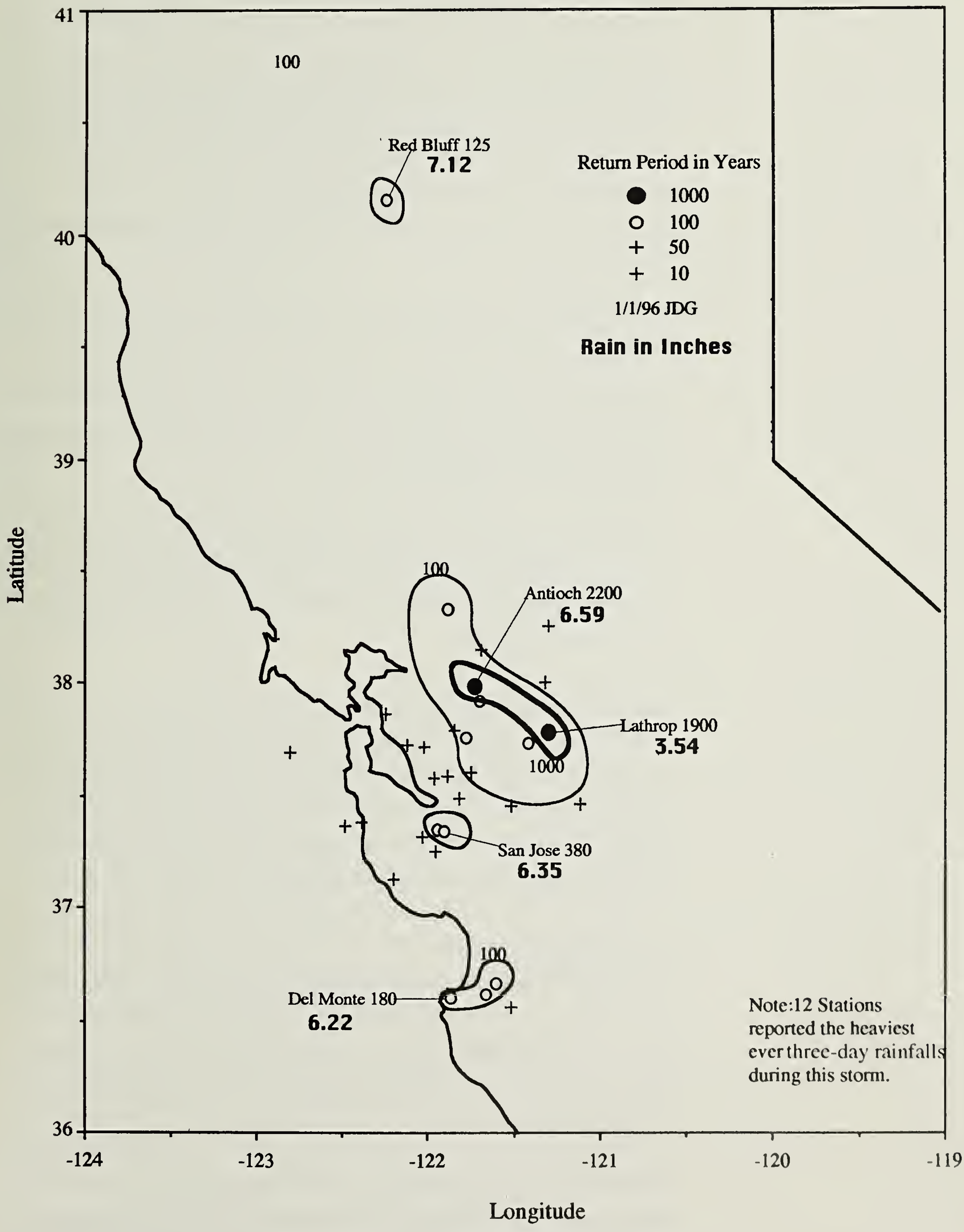
Sweetwater Dam is a landmark case of short-term thinking that at one time plagued dam designers. The original Sweetwater Dam was built in 1888 with a spillway capacity of 1,800 cubic feet per second "which was well in excess of the maximum flood discharge as indicated by high water marks, although a subsequent flood exceeded this capacity a little more than ten times." [28] On January 17 and 18, 1895, Sweetwater Dam was filled to overflowing. The resulting 18,150 second-feet sent 1.5 feet of water over the Dam. "Not a stone of masonry was disturbed to the satisfaction of the dam's owners." [28]

During repairs to the Dam from the 1895 storm, the dam height was raised 5.5 feet and the spillway capacity was increased to 5,500 cubic feet per second. This was adequate until 1916 when a peak flow of 45,500 cubic feet per second occurred, according to the chief engineer of the Sweetwater Water Company.[23] The 1916 storm sent 3.5 feet over the top of the Dam and eroded quite deeply around the north end of the main masonry structure. As of 1991, Sweetwater Dam has a capacity to safely pass 66,800 cubic feet per second, according to the California Division of Safety of Dams.

Descauso received over 27.79 inches of rainfall during January 14-28, 1916. This represents a return period of about 6,400 years. Twenty-five stations had record-high rainfalls during this storm. There were 8 reports of 10-inch-per-day rainfalls on January 17, 1916, the largest at Squirrel Inn in San Bernardino County.

Map 8 Storm of January 14-28, 1916




100
Red Bluff 125
7.12
Return Period in Years
1000
100
50
10
1/1/96 JDG
Rain in Inches
100
Antioch 2200
6.59
Lathrop 1900
3.54
1000
San Jose 380
6.35
100
Del Monte 180
6.22
Note:12 Stations reported the heaviest ever three-day rainfalls during this storm.
41
40
39
38
37
36
Latitude
-124
-123
-122
-121
-120
-119
Longitude

Storm of September 12-14, 1918 (Map 9 on page 33)

The storm of September 12-14, 1918, was centered at Antioch in Contra Costa County where 6.59 inches were recorded in 3 days. It had a return period of 2,200 years. The next greatest return period was at San Jose, where 6.35 inches resulted in a 380-year return period. Twelve stations had their greatest three-day rainfalls during this storm. The highest storm total rainfall was at Red Bluff where they had 7.12 inches. Twelve stations reported rainfalls with return periods in excess of 100 years.

This was the only Mexican coastal hurricane known to come inland as far north as Central California.[23] The storm system apparently moved onshore near Santa Cruz and then moved north to the Red Bluff area before dissipating. Typically these storms bring a surge of warm tropical air that frequently triggers thunderstorms.

This storm is similar to the event of February 10, 1978 in that a strong cyclonic system came onshore into a normally drier area and dropped a very heavy amount of rain in a rain shadow area where heavy rainfalls are not usually expected.

Storm of December 18-22, 1921

The storm of December 1921 produced the largest rainfalls ever at several locations. Werner Springs in San Diego County was the location of the rainfall total with the largest return period of 500 years. Opids Camp, north of Mt. Wilson in Los Angeles County, received the greatest one-day rainfall with 14.89 inches on December 19, 1921.

Storm of April 25, 1925

The storm at Fancher Ranch in Merced County was apparently localized as few other stations reported such a high rainfall. This station has 64 years of rainfall record. There was widespread rain over a broad region on this day. The return period for 4 inches in one day at Fancher Ranch is 6,300 years.

Storm of February 13-17, 1927 (Map 10 on page 36)

Eleven years after the "mother of all storms" in San Diego, a four-day storm dumped 25.38 inches at Henshaw Dam. This was a 5,000-year

storm. The Henshaw weather station reported 14.48 inches on February 16, 1927.

Thirty-nine stations reported the greatest four-day rainfall of record during this storm. Six stations had 1,000-year rainfalls. The station with the most rain was Raywood Flats in Riverside County which had 26.60 inches.

Storm of September 28 - October 1, 1932

Moisture from the Tehachapi storm created a scene for disaster. It resulted in a million dollars in damages and the loss of 15 lives. This storm occurred in Caliente Creek, which drains into the San Joaquin Valley.

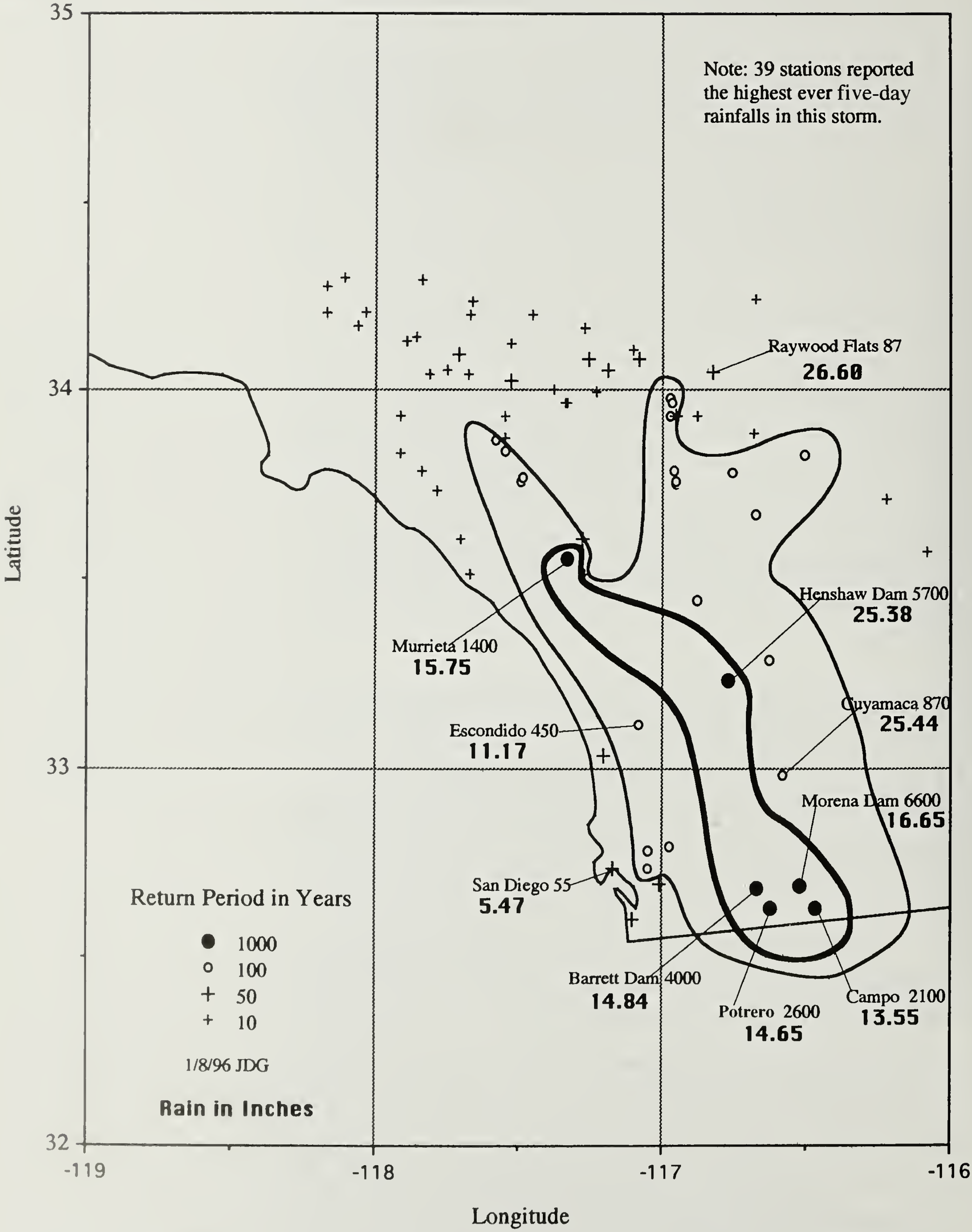
The Tehachapi storm was associated with a tropical disturbance off the coast of Guatemala on September 24, 1932.[10] This storm traveled up the Gulf of California and came onshore south of Mexicali on September 29. It came into the lower desert without much resistance, only to break up in the Tehachapi Mountains of Southern California. Tehachapi received 7.11 inches of rain in four days. This was a 200- to 500-year storm at Tehachapi. Apparently the rainfalls exceeded this in the surrounding mountains.

The storm was described by Malcolm Sprage in *Climatological Data* for October 1932, " Destruction was great near Woodford where a service station was washed away and two freight engines and six box cars dropped into a gully formed when the approach to the railroad bridge at that place was destroyed. One of the engines was so deeply buried under silt and rocks that it was not found until five days later. Railway traffic was interrupted for 14 days and highway traffic for 2 days."[2] Further details of this disaster were described in *Three Barrels of Steam* by James E. Boynton. Reports are long on details of the storm's effects and short on quantitative details of the rainfalls.

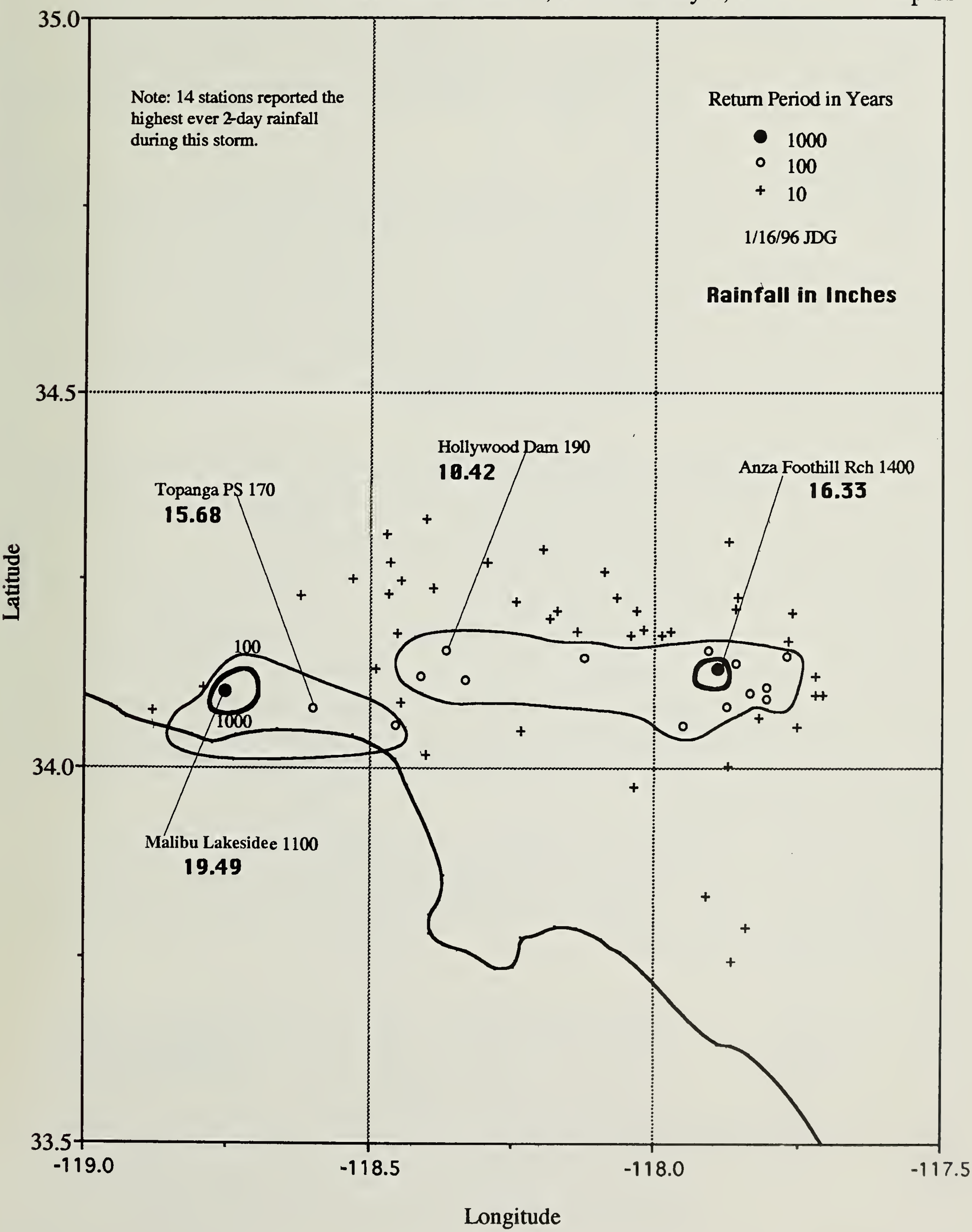
Storm of December 31, 1933 - January 1, 1934 (Map 11 on page 37)

New Year's Day 1934 was spent mopping up, after some of the greatest rainfalls ever on the south slope of the San Gabriel Mountains. The heavy part of the storm extended from Malibu in the west to Covina in the east. The heaviest rainfalls, based on standard deviation above the mean, was at Anza Foothill Ranch where 16.33 inches of rainfall had a

Map 10 Storm of February 13-17, 1927



Storm of December 31, 1933-January 1, 1934 Map 11



1,200-year return period.

An enormous debris flow followed the heavy rainfall in La Canada Valley northwest of Pasadena. This was disastrous to those living downstream.

The debris flow was made worse because a forest fire in November 1933 had completely denuded much of the watershed of its vegetative cover just before the rainy season. The fire was in the watershed of Verdugo Creek, a tributary of the Los Angeles River upstream from Glendale. The area with the most damage was upstream from Montrose. The New Year's flood of 1934 took the lives of more than 40 people and caused $5 million in property damage.[29]

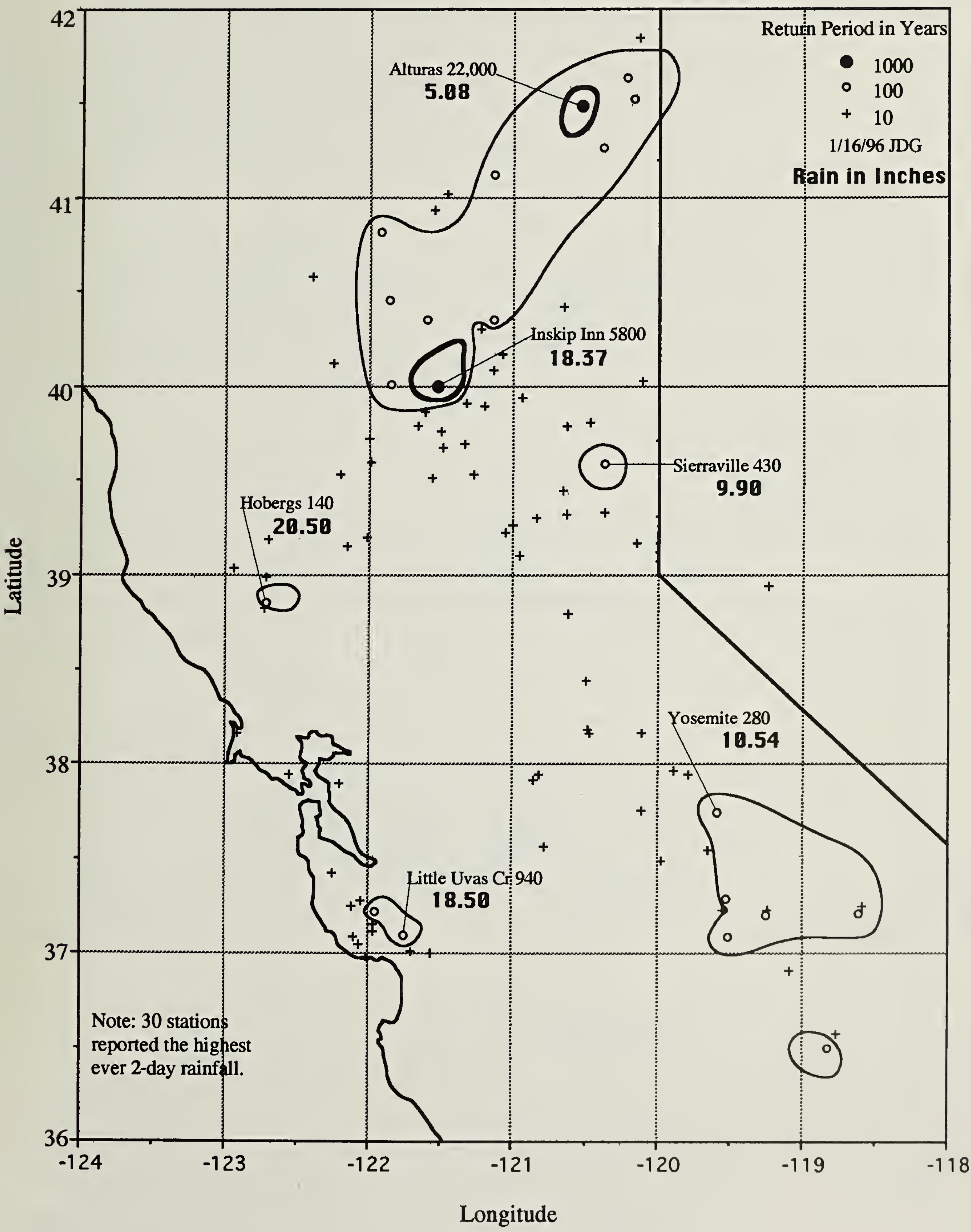
There were 16 reports of daily rainfalls in excess of 10 inches. Hoegees was the wettest with 14.81 inches on New Year's day. Fourteen stations reported the greatest two-day rainfall of record.

Storm of December 10-11, 1937 (Map 12 on page 39)
This was a high-elevation storm located in the northeast corner of the State. Thirty-one stations reported the greatest two-day rainfall. The high-intensity part of this storm was centered in a zone between Inskip Inn in eastern Butte County to Alturas in Modoc County. Alturas had 5.08 inches of rainfall which represented a 22,000-year return period.

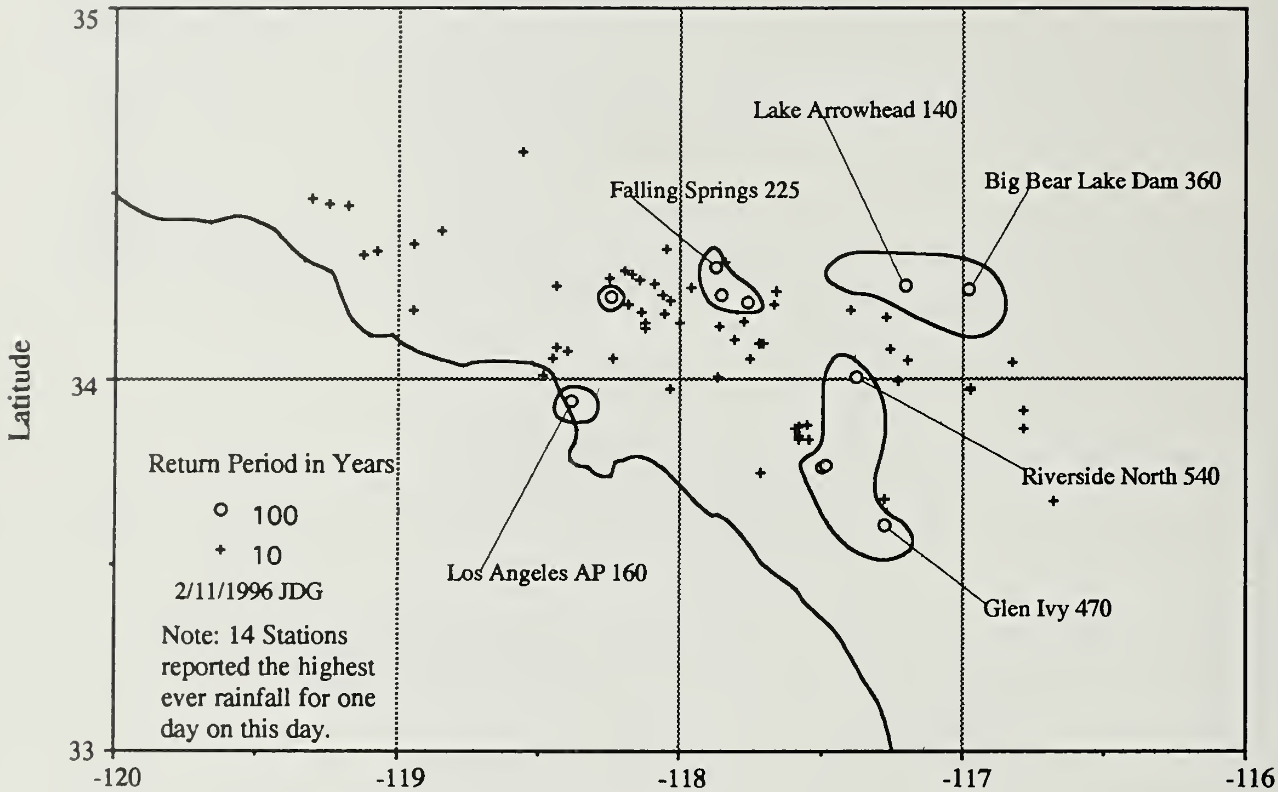
Five stations reported over 10 inches of rainfall on December 11, 1937. Cobb in Lake County received the largest amount with 13.65 inches on December 11. The largest storm total was at Hobergs with 20.50 in two days.

Storm of March 2, 1938 (Map 13 on page 40)
The storm of March 2, 1938, produced some of the largest streamflows recorded in Southern California, over a broad range of streams, mainly in Los Angeles and San Bernardino Counties. According to records analyzed so far, this storm did not produce a 1,000-year rainfall. However, it did result in 33 to 50 percent of the average annual rainfall in one day. The largest return period was 540 years at Riverside North.

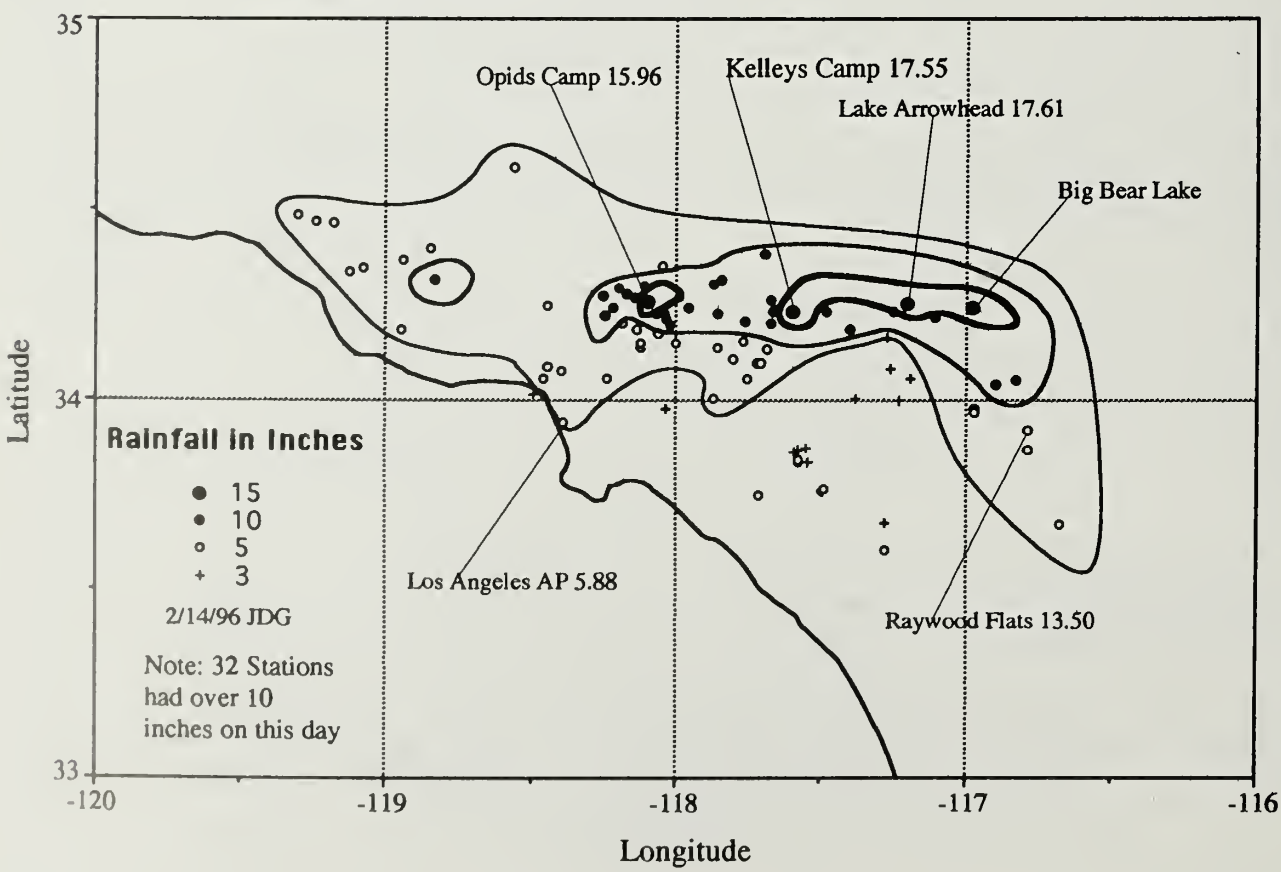
Storm of December 10-12, 1937 Map 12



Map 13 Storm of March 2, 1938



Rainfall for March 2, 1938



A remarkable feature of this storm was the number of large rainfalls with small return periods. More than 10 inches in one day was reported from 17 stations on March 2, 1938. Thirty-two stations reported the largest ever rainfall in one day. This is a region where large rainfalls are a relatively common occurrence. For example, a 15-inch daily rainfall at Opids Camp in the San Gabriel Mountains has a return period of less than 25 years.

A study of the floods of this storm published by Harold C. Troxell, *Floods of March 1938 in Southern California*, indicated that 87 lives were lost and $78 million in damages occurred.[30] This Water Supply Paper also contains an interesting descriptive history of flooding in Southern California from 1780.

An example of this storm's effects on streamflow is Arroyo Seco near Pasadena (USGS# 11098000), a stream with a continuous record of streamflow since 1915. There are no water diversions or storage above the gaging station. The highest recorded gage height was 9.42 feet or 8,620 cubic feet per second for the 16-square-mile watershed on March 2, 1938. A high-intensity, short-duration storm might have been buried in the daily rainfalls totals.

Storm of September 5-6, 1939

This storm was one of four tropical storms that affected Southern California during September 1939.[10] It was first tracked west of La Paz on September 4, then moved northwest where it was caught in a cold front and forced over the mountains of Baja California into the Imperial Valley region. The surge of tropical air also induced heavy rainfall in Northern Arizona.

Brawley 2 SW received 6.33 inches of rainfall on September 5 and 6, 1939. The mean annual precipitation at Brawley is 2.63 inches, based on a 65-year record. This two-day event was 2.4 times the average annual rainfall for Brawley. It has a return period of about 16,000 years. Several other desert stations reported the highest two-day rainfall totals during this period. During this storm, Metropolitan Water District of Southern California's pumping plant at Iron Mountain and at Hayfield both reported more than 5 inches, a 1,000-year rainfall event.

Storm of September 24, 1939

One of the most interesting storms in California was at Indio in the Salton Sea drainage area. The runoff resulting from this storm caused a barely detectable rise in the Salton Sea.

A tropical cyclone formed 10 days earlier, south of El Salvador.[1] The meteorological aspects of this, and many important California storms were studied by Weaver, who indicated that this was a tropical storm which came ashore near San Pedro.[26] The storm crossed over the mountains where the outstanding rainfalls occurred in a rain shadow zone in the low desert. There was over $1.5 million in damage where it came onshore.

Hurricanes typically infuse a region with warm moist air in which thunderstorms are generated. The Indio thunderstorm could be compared to the Red Bluff thunderstorm of September 14, 1918, which also followed a surge of marine air after a hurricane. The rainfall at Indio represents 8.8 standard deviations, which is a return period of about 55,000 years in this region.

This storm was studied by Charles B. Pyke, who found that twice the mean annual precipitation of 3.43 inches occurred in six hours.[31] California has 20 stations where the maximum daily rainfall is larger than the average annual rainfall, but at none of the stations is the daily rainfall this extreme.

Pyke reports that this was a thunderstorm. Large rainfalls occurred as far away as Imperial, located 70 miles southeast of Indio. The 4.08 inches of rain at Imperial indicates a return period of 2,200 years.

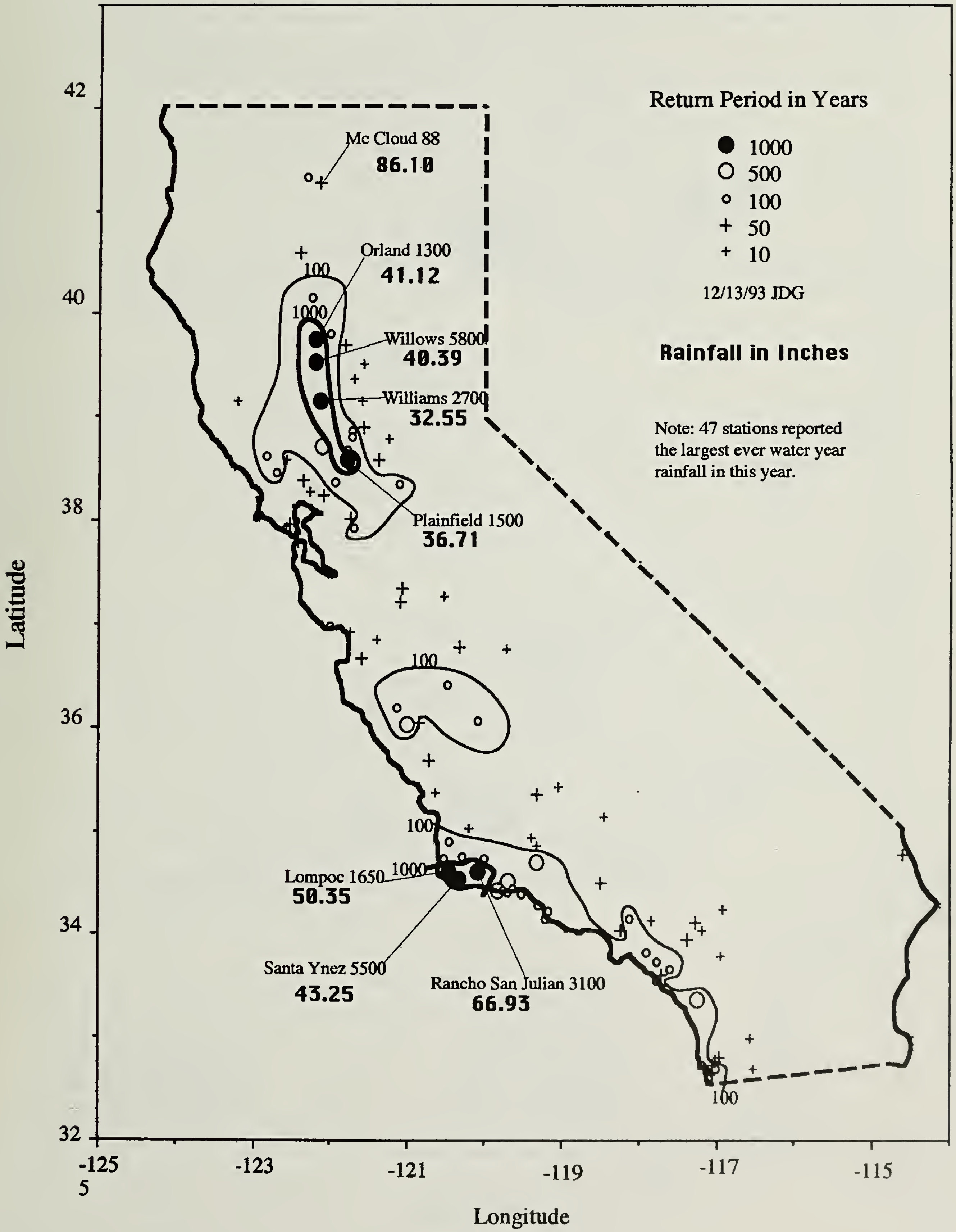
Water Year 1941 (Map 14 on page 43)

The heavy rains of 1941 were mainly confined to the Sacramento Valley but a narrow strip extended from Santa Barbara County to Orange County. Both Willows and Santa Ynez had rain totals for the year with return periods in excess of 5,000 years.

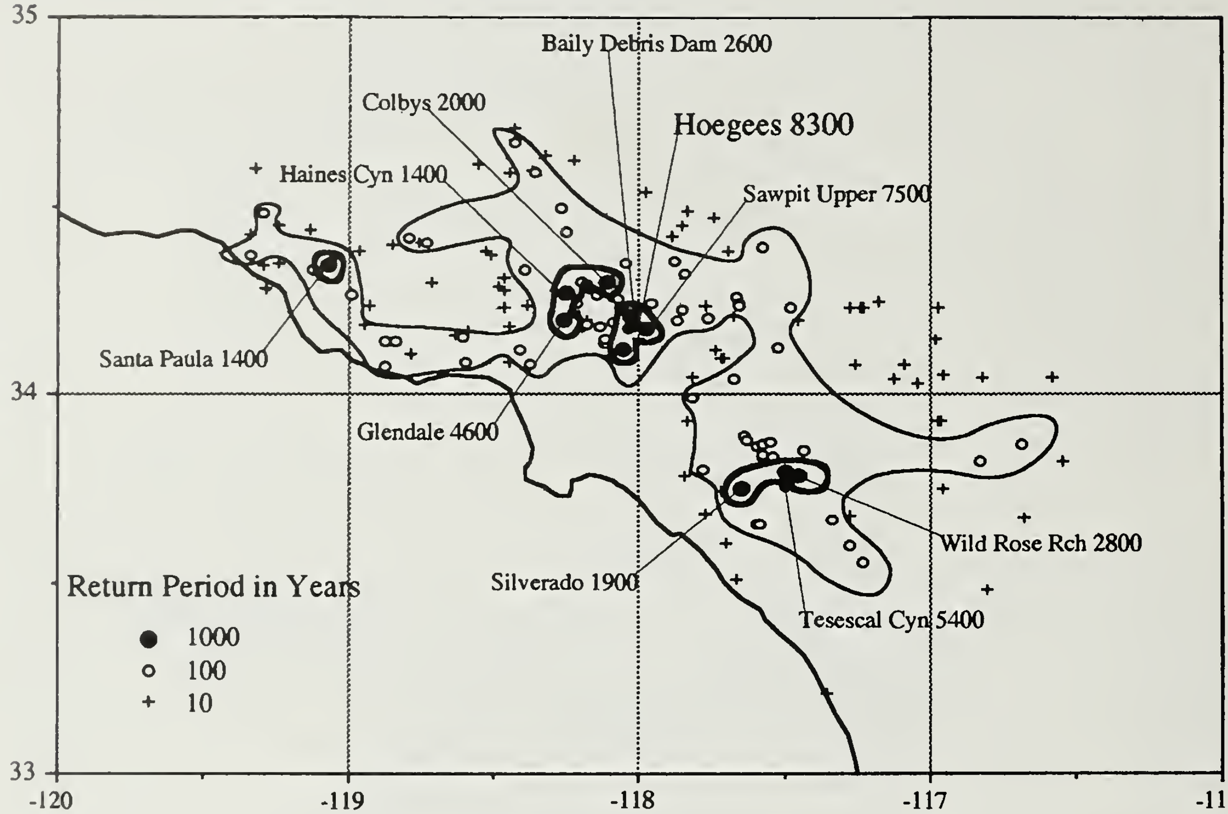
Storm of January 22-23, 1943 (Map 15 on page 44)

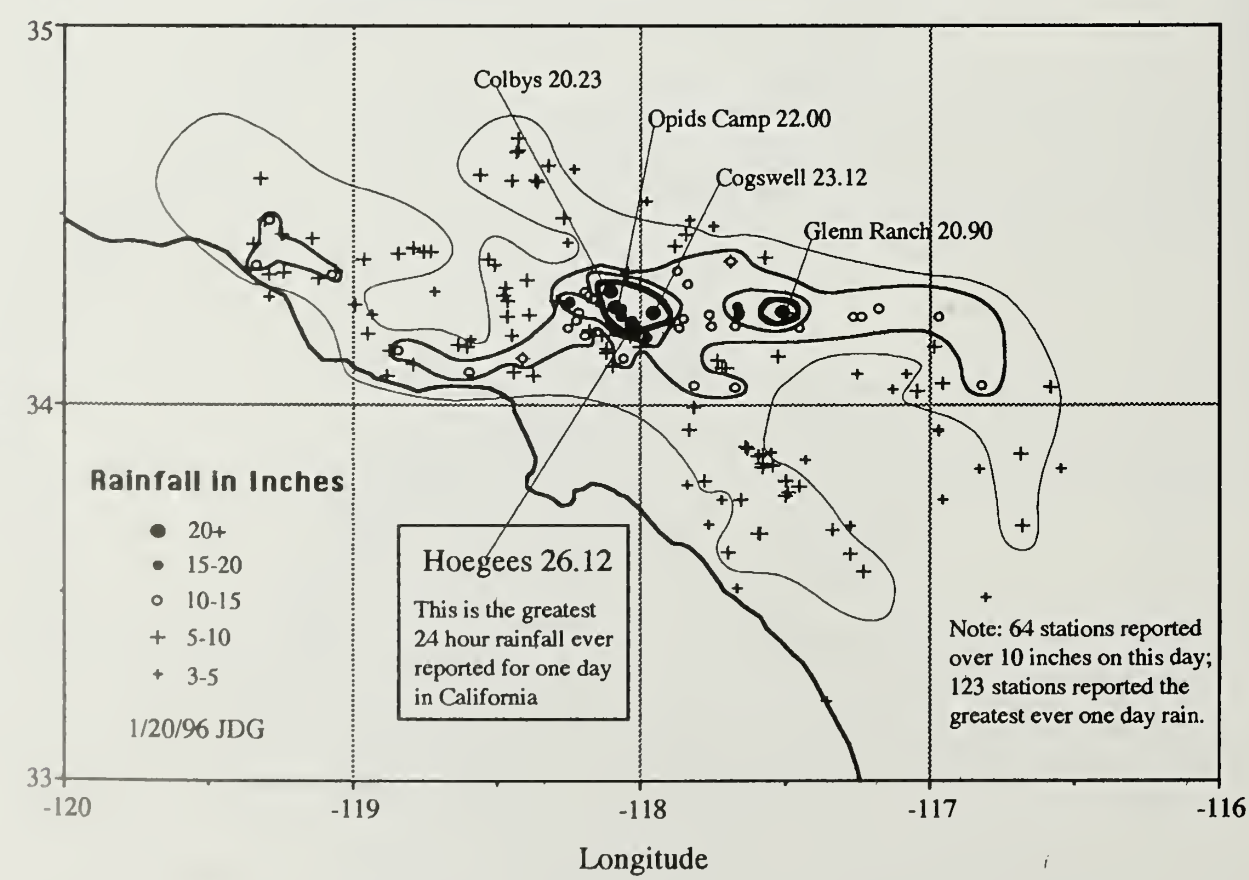
The greatest daily rainfall recorded in California was 26.12 inches on

Rainfall for Water Year 1941 Map 14



Map 15 Storm of January 22-23, 1943





January 23, 1943, at Hoegees, near Mt. Wilson in the San Gabriel Mountains, north of Los Angeles. Twenty-six inches was 96 percent of the mean annual precipitation for Hoegees. This is an area which normally gets 18 percent of its annual rainfall on the wettest day of the year. Hoegees had 10-inch-per-day rainfalls on eight other occasions. At Hoegees, 26.12 inches in one day is 6.73 standard deviations over the mean, with a return period of 11,000 years.

Fifty-eight stations reported daily rainfall totals of over 10 inches on January 22, 1943. These were located in Los Angeles and San Bernardino Counties.

The largest return periods over the region covered by the storm were associated with two-day storm totals. Hoegees had 36.34 inches of rain in two days, a return period of 5,400 years. Highest ever rainfalls were reported from 125 stations. Fifteen stations had over 20 inches in two days. Forty-five stations had 70 percent of the average annual rainfall in two days.

The extremely high rainfall of January 23 is limited to a relatively small area near Mt. Wilson. There was an area of 11,000 square miles ranging from Santa Barbara County to Riverside County which received a soaking from this storm, in excess of a once-in-a-hundred year storm.

Storm of October 29, 1950

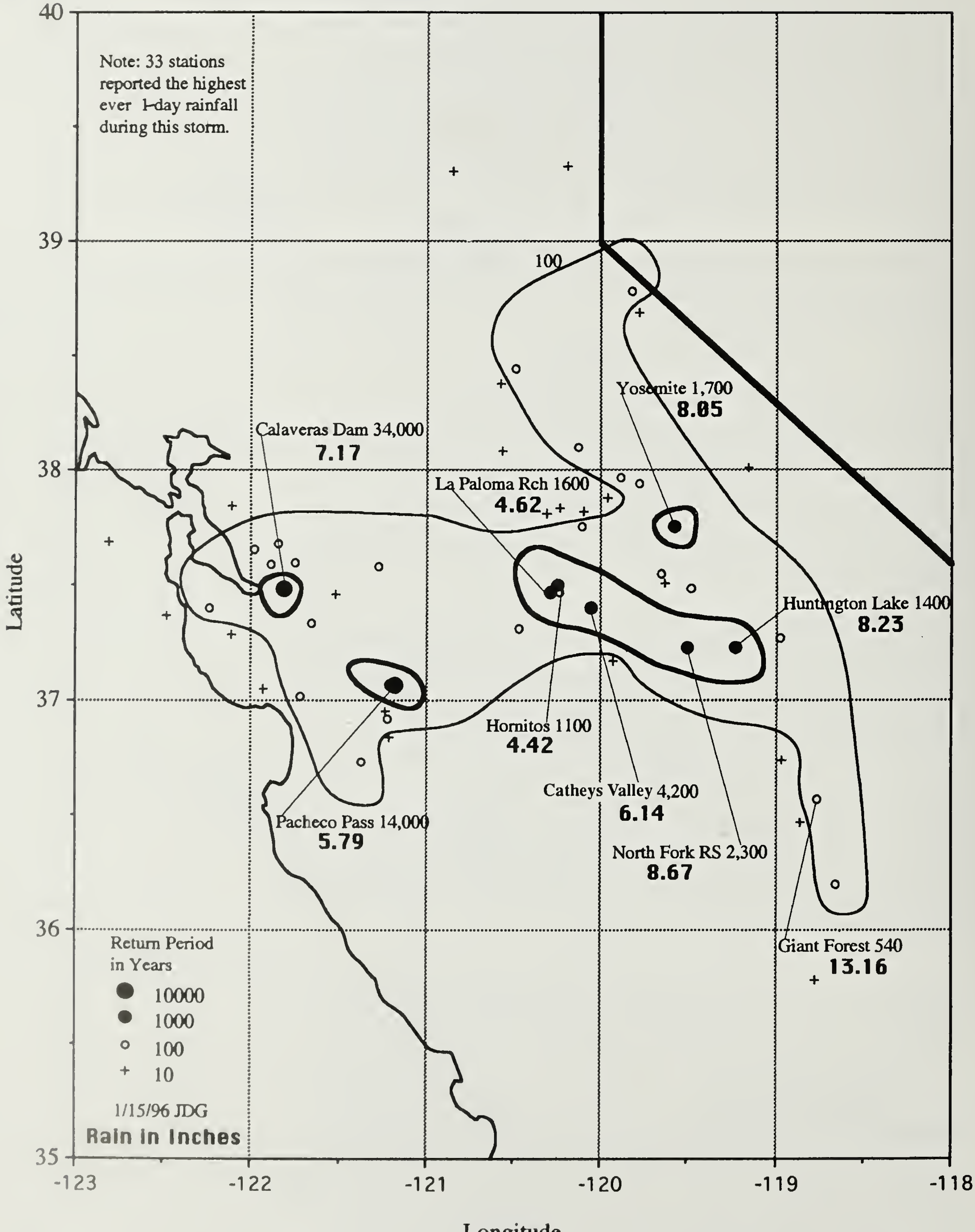
Orick's greatest one-day rainfall occurred when 11.50 inches were recorded. The Orick rainfall was 5.71 standard deviations above the mean with a return period of 4,200 years.

Gasquet Ranger Station reported 10.35 inches. Eureka, Crescent City, and Happy Camp also reported their greatest daily rainfall.

Storm of November 18, 1950 (Map 16 on page 46)

This typical high-elevation storm passed through Central California. The rainfall distribution in this storm is quite similar to the January 30-February 1, 1963 storm (compare Maps 16 and 19). Both storms had heavy rainfall in the coastal mountains as well as in the Sierra. The 1963 storm affected areas south of the wetter zone of this storm.

Map 16 Storm of November 18, 1950



The greatest one-day total rainfall for this storm was 13.16 inches at Giant Forest in Tulare County at an elevation of 6,412 feet. Greatest ever daily rainfalls were reported at 30 stations. Twenty stations received 25 percent of the average annual rainfall on this day.

Nine stations reported 1,000 year rainfalls, seven of which were in the Stanislaus, Merced, and San Joaquin Rivers. The station reporting the largest return period was Calaveras Dam in Alameda County. Calaveras Dam received 7.17 inches in one day, which was 33 percent of its mean annual precipitation. The return period for Calaveras Dam was 23,000 years.

State Highway 140 into Yosemite was washed out near El Portal. Extensive flooding was reported, mainly on the lower San Joaquin River.[32]

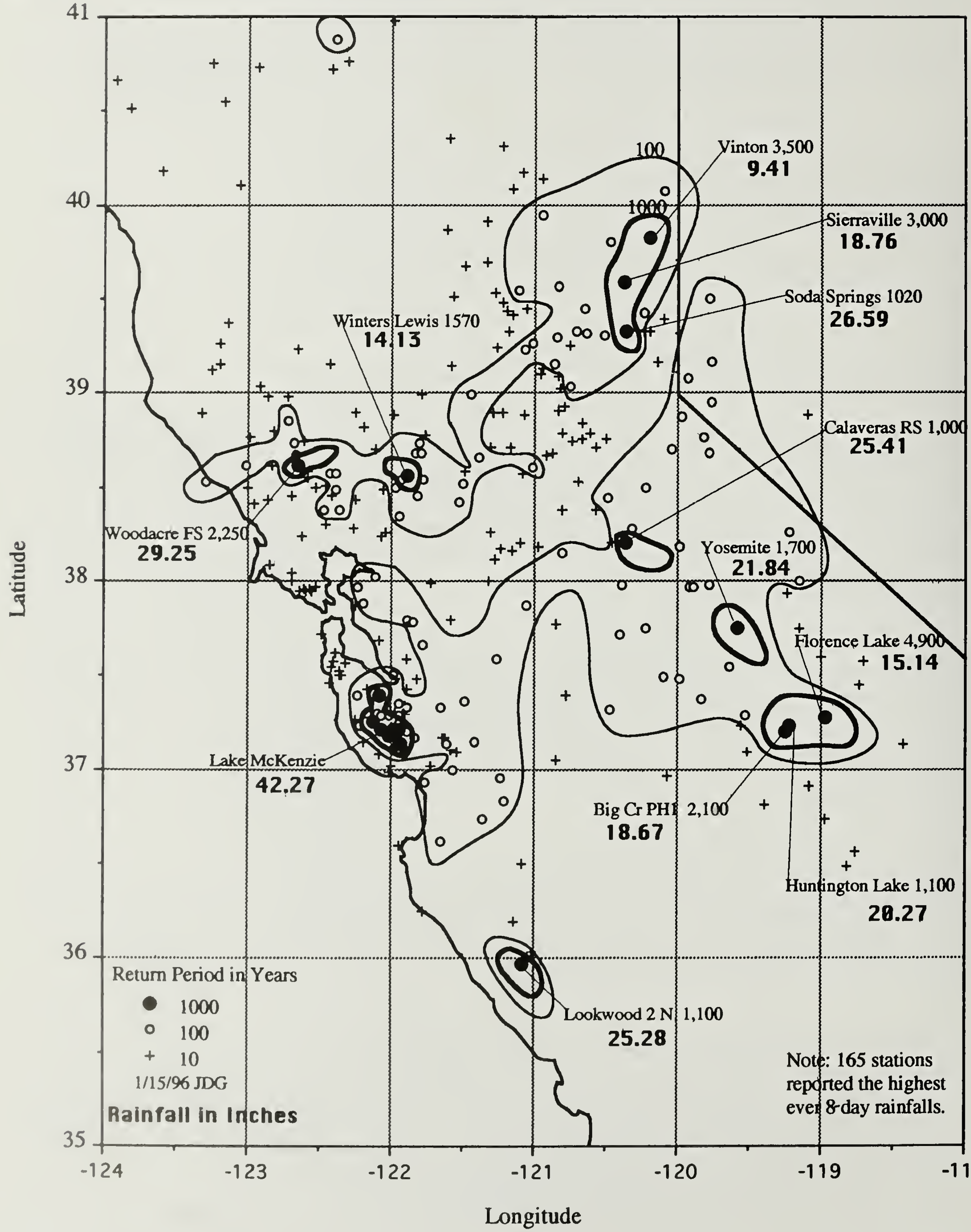
Christmas Storm of December 19-27, 1955 (Map 17 on page 48)
This warm storm melted accumulated snowfall up to an elevation of 10,000 feet. It did not produce heavy short bursts of rain but continued all week with few breaks. It saturated the soil, filled the surface reservoirs, and resulted in extensive flooding.

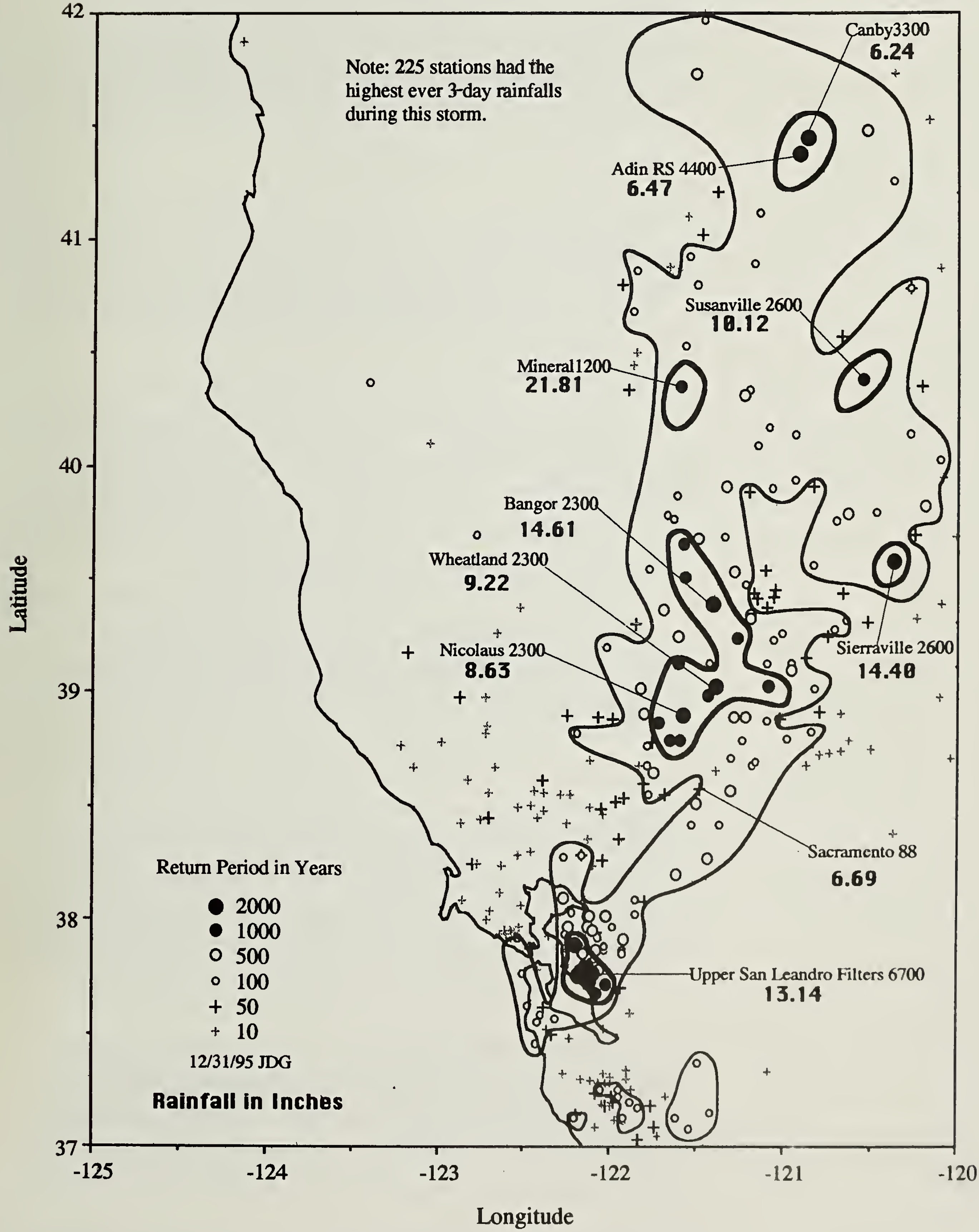
The largest return periods associated with this storm were for eight-day rainfall totals. This storm primarily affected the central Sierra Nevada, which includes the Feather, Yuba, Bear, American, Cosumnes, and Calaveras Rivers. The Russian and Napa Rivers and south Bay Area streams were also affected.

This was, in general, a high-elevation storm in both the Coastal Mountains and the Sierras. Twenty stations reported storm intensities in excess of the once-in-a-thousand-year storms, during December 1955. Santa Clara Valley was the hardest hit in terms of large return periods.

Over half the stations reporting a once-in-a-hundred-year storm were located at an elevation over 1,000 feet. The greatest for the Sierra stations was 36.57 inches at Strawberry Valley in the Yuba River drainage area. In the Santa Clara Valley, the maximum was 42.27 inches at Lake McKenzie, located southwest of San Jose at 1,800 feet. The maximum eight days of rainfall of 49.20 inches was reported at Honeydew in the Mattole River drainage area.

Map 17 Storm of December 19-27, 1955




Note: 225 stations had the highest ever 3-day rainfalls during this storm.
Canby3300
6.24
Adin RS 4400
6.47
Susanville 2600
10.12
Mineral1200
21.81
Bangor 2300
14.61
Wheatland 2300
9.22
Nicolaus 2300
8.63
Sierraville 2600
14.40
Sacramento 88
6.69
Upper San Leandro Filters 6700
13.14
Return Period in Years
2000
1000
500
100
50
10
12/31/95 JDG
Rainfall in Inches
Latitude
Longitude
42
41
40
39
38
37
-125
-124
-123
-122
-121
-120

Nineteen stations reported daily rainfall in excess of 10 inches in one day during the 1955 storm. These were located in the upper Sacramento, Feather, and San Joaquin Rivers and in the Clear Lake area. The heaviest 24-hour rainfall recorded for the Central Valley, up to this time, was on December 20, when 15.34 inches fell at Lakeshore in Shasta County in the Upper Sacramento River Basin.

Storm of April 3, 1958

A series of storms off the coast with an associated series of fast-moving fronts swept over California during late March and early April 1958. The San Joaquin Valley experienced several small tornadoes. Thunderstorms were widespread.

One of the largest storms occurred at Woodward Dam, located seven miles northwest of Oakdale, in Stanislaus County. Woodward Dam received 5.72 inches of rain, 45 percent of its average annual rainfall. The return period approached 300,000 years, as this was 8.55 standard deviations above the average maximum daily rainfall.

This was a very localized storm, as only Hogan Dam and Drytown reported the record high one-day rainfall. Dry Creek near Galt had a peak streamflow which was exceeded only by the February 1986 storm.

Columbus Day Storm of October 11-13, 1962 (Map 18 on page 49)

The Columbus Day Storm is remembered for high winds, as well as for record-breaking rainfalls. Millions of trees were blown down along the coastal areas from Washington State to Central California.[33] This storm started as Typhoon Freda near Wake Island nine days earlier and merged with a cold front to become an intense midlatitude cyclone.[1] A peak gust of 170 mph was reported at Mt. Hebo located west of Salem, Oregon.

In California, heavy rainfalls covered a wide band extending from Oakland to Alturas. Oregon experienced 170 mph winds. The storm caused $250 million in damage and as many as 56 lives were lost. This storm came at the end of the normal summer drought when the ground was dry, or flooding would have been much worse.

As many as 225 stations reported the greatest three-day rainfall totals

recorded. Lake Spaulding had 23.05 inches of rainfall, the greatest three-day rainfall of its 93-year record. Marysville received 9.26 inches. The greatest three-day rainfall for this storm was 25.78 inches reported at Forbestown in the Feather River Basin. This storm included low-elevation locations, suggesting that it was not exclusively an orographic type storm.

Thirty stations received half of their annual mean precipitation. Seventeen stations reported rainfalls in excess of 20 inches. Twenty-three stations reported over 10 inches of rainfall. Ben Lomond, north of Santa Cruz, reported the greatest one-day total with 14.10 inches.

Twenty-five stations reported rainfalls in excess of the 1,000-year return period. The greatest return period was for Orinda Filters where 18.41 inches corresponded to a 6,500-year return period. This was similar to the return periods at several other stations in Alameda and Contra Costa Counties.

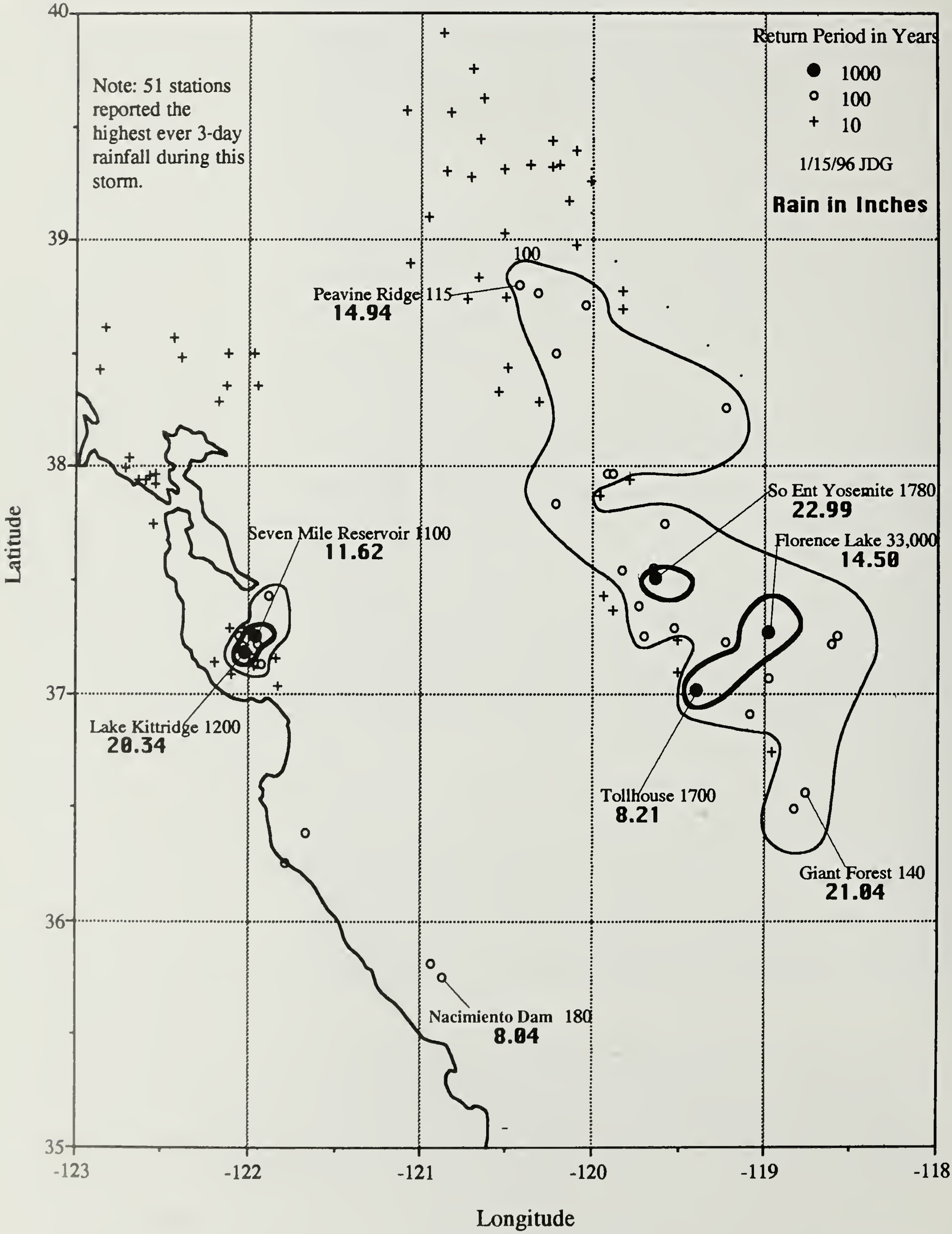
Storm of January 30 - February 1, 1963 (Map 19 on page 52)
This storm, after one of the worst midwinter droughts in California, produced the greatest three-day rainfalls at high-elevation stations in the Sierra. Record numbers of midwinter foggy days were recorded in Sacramento which were associated with high barometric pressures and stagnant winds.

Forty-five stations reported greatest ever three-day rainfalls. The greatest rainfalls were centered south of Yosemite. Florence Lake received 64 percent of its mean annual precipitation, which represents a return period of 33,000 years. Yosemite National Park's south entrance and Tollhouse are other Sierra stations with a 1,000+ year return period.

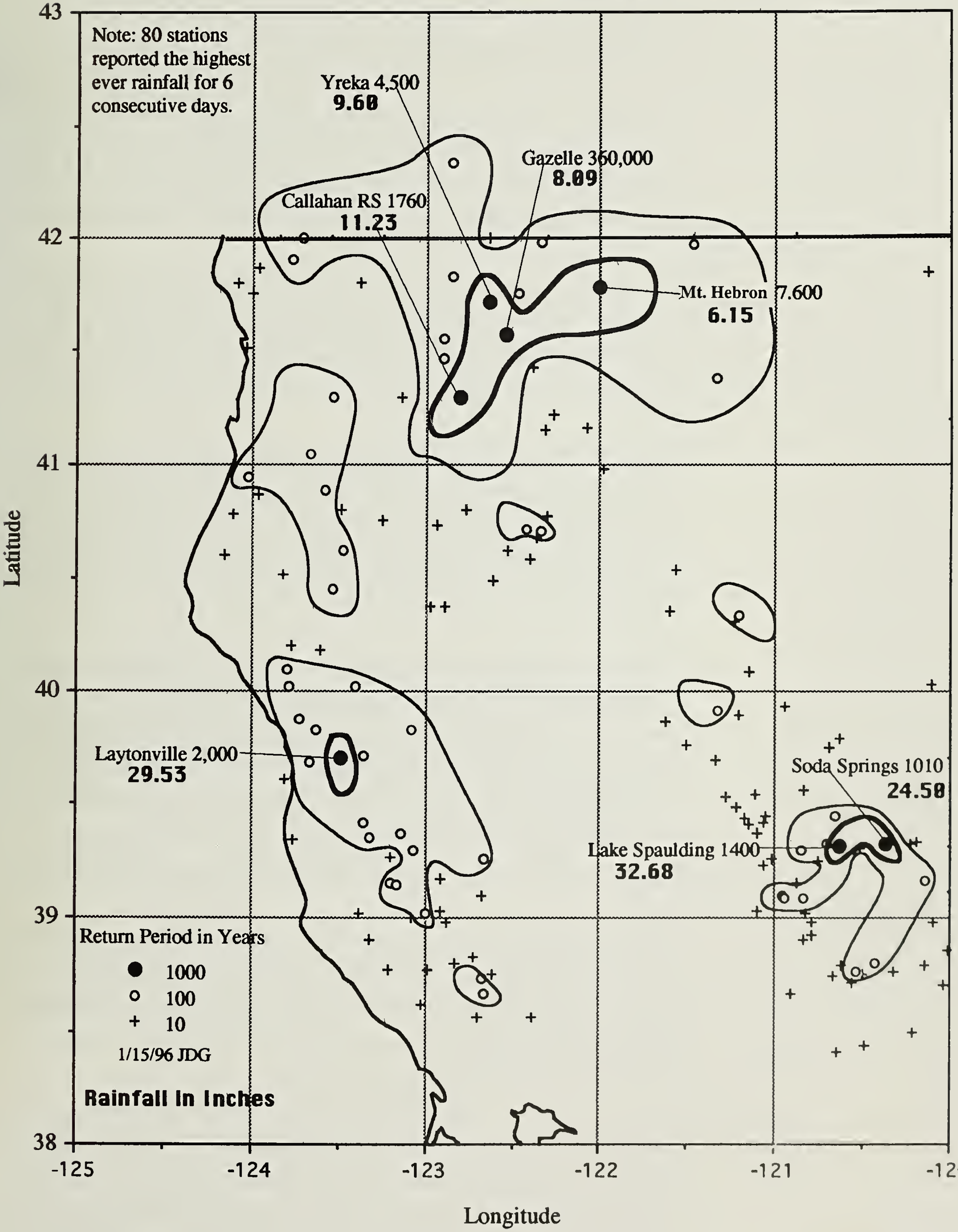
Nine stations in Santa Clara Valley reported the greatest three-day rainfalls during this storm sequence. Lake Kittridge and Seven Mile Reservoir both reported rainfalls in excess of the 1,000-year event. Several Santa Clara Valley stations reported 20 inches of precipitation in this three-day storm.

The highest one-day rainfalls were at Big Bend Ranger Station and

Map 19 Storm of January 30-February 1, 1963



Storm of December 19-24, 1964 Map 20



Cherry Valley Dam, both which received over 10 inches on February 1, 1963. The greatest storm totals were 23.25 inches at Wishon Dam and 22.99 inches at Yosemite's south entrance.

The snow line associated with this storm was generally over 8,000 feet and at times as high as 11,000 feet. Snow melt was a major factor in the flooding associated with this storm. Many streams reported record high flows during this storm.[34]

This storm resulted in extensive flooding at Reno (Nevada), Marysville, and Napa. The return period of rainfalls in the American River Basin ranged from 10 to 80 years in the north to 200 years at Twin Lakes at the South Fork.

Christmas Storm of December 19-24, 1964 (Map 20 on page 53)
These were the wettest days recorded at 78 stations on the northwest coast, and the worst flooding ever experienced in that region. Every major stream produced new high values of extreme peak flows. Thirty-four counties in California were declared disaster areas.

This storm had three major centers of activity: the Eel River, the upper Klamath River, and the Yuba River in the central Sierra Nevada. The greatest six-day rainfall for Eel Basin was 31.71 inches at Branscomb. Fourteen of 17 stations in the Eel River Basin reported the greatest rainfalls during this storm. A telephone pole stands at the former town site of Weott along the Eel River with a sign near the top to remind people of the great depth of the water during the December 1964 flood.

The greatest return periods for the storm were in the Klamath River Basin where Gazelle reported 8.09 inches. This was 7.78 standard deviations above the mean. The associated return period is over 300,000 years. These very high numbers were also reflected in the records of nearby stations of Yreka, Mt. Hebron, and Callahan.

Streamflow on the Yuba River at Marysville peaked at 180,000 cubic feet per second, causing the second Christmas-time flood in a decade. The December 1955 peak on the Yuba River at Marysville was 140,000 cubic feet per second. The greatest rainfalls occurred in the

Yuba and Bear river basins, where Lake Spaulding received 32.60 inches of rainfall in six days. Six stations in the Yuba watershed reported over 10 inches of rainfall on December 22, 1964.

In terms of return periods, the zone which exceeded a once-in-a-hundred-year rainfall extended from Calistoga north along the Del Norte-Trinity County line and northeast to Tule Lake where they had 4.07 inches in six days which exceeded a once-in-700-year return period.

Thirty-five stations reported daily rainfalls of 10 inches or more on December 22, 1964. These stations are located in the northern coastal streams, as well as the central Sierra Nevada. The greatest reported rainfall in one day is 15 inches at Ettersberg in Humboldt County.

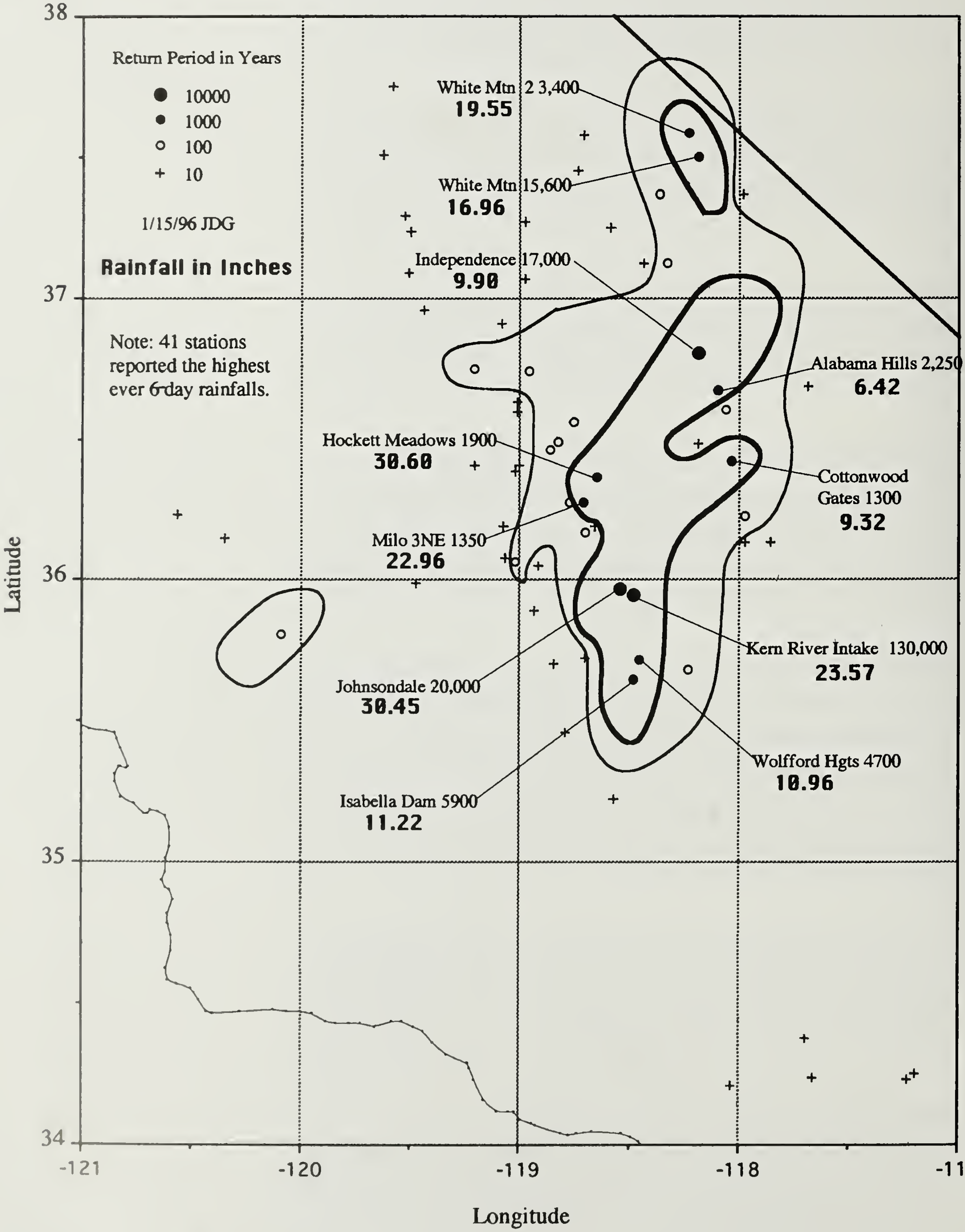
Storm of December 2-7, 1966 (Map 21 on page 56)
This storm took place in the upper Kern River and Owens Valley region. The heaviest band ranged from Southern California Edison Company's Kern River Intake #3 in the south to the White Mountains, over a hundred miles to the northeast.

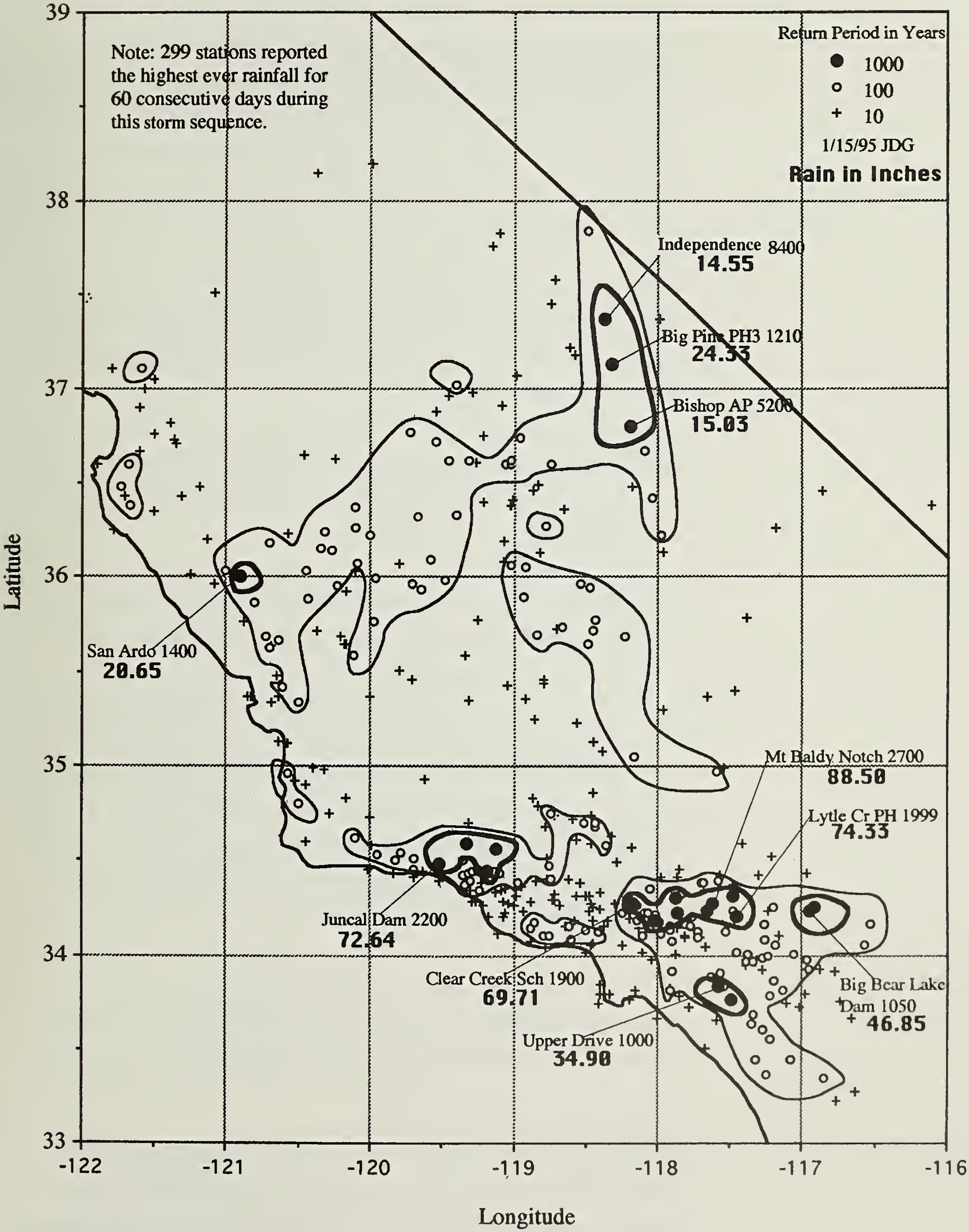
Previous record peak flows and three-day storm-runoff volumes in the Kern, Tule, and Kaweah basins were exceeded by the floods of December 1966.[35] Nineteen stations reported 10 inches or more on December 6. These stations are located mainly in Tulare and San Bernardino Counties. The greatest ever one-day rainfall for the Central Valley was 17.0 inches at Hockett Meadows on December 6, until it reached 17.4 inches in February 1986.

Forty-two rainfall stations reported the greatest five-day rainfalls for this storm. Eleven stations reported 1,000-year rainfalls. The greatest rainfall was reported at Johnsondale with a five-day total of 30.45 inches.

Winter Storms of 1969 (Map 22 on page 57)
Southern California and the southern Sierra Nevada experienced some of the most severe flooding since 1938. Property damage was extensive along the Southern California coastline. Forty counties were declared

Map 21 Storm of December 2-7, 1966





Note: 299 stations reported the highest ever rainfall for 60 consecutive days during this storm sequence.
Return Period in Years
1000
100
10
1/15/95 JDG
Rain in Inches
Independence 8400
14.55
Big Pine PH3 1210
24.33
Bishop AP 5200
15.03
San Ardo 1400
20.65
Mt Baldy Notch 2700
88.50
Lytle Cr PH 1999
74.33
Juncal Dam 2200
72.64
Clear Creek Sch 1900
69.71
Big Bear Lake Dam 1050
46.85
Upper Drive 1000
34.90
Latitude
39
38
37
36
35
34
33
-122
-121
-120
-119
-118
-117
-116
Longitude

disaster areas. Forty-one deaths were directly attributed to the storm.

One of the deaths resulting from this storm was Mr. William Brooks, the weather observer and dam tender at Juncal Dam on the Santa Ynez River in Santa Barbara County. The cabin occupied by Mr. Brooks was washed away on January 26, after he had measured 25.67 inches of rain. Civilization owes much to weather observers like Mr. Brooks who have given so much to future generations.

Thirty stations reported rainfalls in excess of 10 inches per day during the big storm of January 25. The same region received heavy rainfall a month later when Juncal Dam in Santa Barbara County received 16.31 inches on February 25, 1969.

Over 200 stations, mainly in Southern California, reported the greatest recorded rainfall for 60 days. The largest return periods of this study were also associated with 60-day rainfall totals.

Mount Baldy Notch, at 7,735 feet in the San Gabriel Mountains, reported 88.50 inches of rainfall from January 13 to March 13. Mount Baldy Notch is located near the Los Angeles-San Bernardino county line. From Cottonwood Creek at 10,600 feet in the southern Sierra to Death Valley at 194 feet below sea level, extremely high rainfalls for the 60 days were reported. Thirteen stations reported rainfall totals in excess of the calculated once-in-a-thousand-year storm depths. Stations reporting a 1,000-year storm from the South Coast Basin were at higher elevations; however, San Joaquin Valley stations also recorded heavy rainfalls with high return periods.

That winter had the second largest daily rainfall for the State when 24.92 inches of rain fell at Lytle Creek Power House, at 2,225 feet, in the San Gabriel Mountains northwest of San Bernardino.

Snowmelt Floods of Spring 1969

By April 1, one of the greatest snowpacks had accumulated in the southern Sierra, containing over 200 percent of the average water content. Tulare Lake Basin, the site of 100,000 cultivated acres, flooded 89,000 acres of cropland in order to provide storage for the melting

snow. This could be called the "Tulare Lake Storm." Tulare Lake is normally a dry lakebed, fully cultivated and the former terminus of the Kings River. The Pine Flat Dam holds 59 percent of the mean annual flow of the Kings River. Tulare Lake lies in the rain shadow of the Coast Ranges and is normally protected from large Pacific storms. The mean annual precipitation is 6 inches.

Storm of December 3, 1970

Apparently, Harrison Gulch Ranger Station was the only site recording this large storm. The recording gage reported 12.30 inches on this day.[8] The puzzling thing is that a nonrecording gage at the same station had only .45 inches.[2]

A heavy rainfall did occur on December 3, 1970, because upper Sacramento Valley creeks, including Cottonwood Creek, indicated a sharp rise in flow on this day. This storm needs further study.

Storm of 1975

A storm at Fieldbrook in Humboldt County produced 10.30 inches in one day. The return period is 2,000 years.

Storm of September 10-11, 1976

Heavy rainfall was associated with Tropical Cyclone Kathleen, located at Latitude 15° N on September 6. It moved over the Imperial Valley by September 10. According to James R. Fors, this storm caused five deaths in the United States and more than $150 million in storm-related damages.[36] This storm was notable because it went as far north as Idaho and Montana on September 11-12, causing high winds and isolated heavy precipitation.

Although the lowest rainfall for two consecutive years of California weather history were 1976 and 1977, it is not unusual to have a drought punctuated with "gully washers."

The highest one-day rainfall for this storm was 12.10 inches at Fallsdale in the Santa Ana River Drainage. Mecca had 4.00 inches which was well in excess if its average annual rain for 78 years of 3.24 inches. The return period for Mecca was 740 years. Thirteen stations had the highest ever

rainfalls from this storm.

Storm of August 16, 1977

Tropical Cyclone Doreen occurred off the west coast of Baja California near La Paz on August 15, after moving north out of the tropics, then continued north to come ashore near San Diego early on August 16. Rainfall was heavy in the Imperial Valley, where irrigation canals were breached. The town of Niland was flooded.[1]

Five deaths were attributed to flooding from Tropical Cyclone Doreen rainfalls.[37] Damage was extensive, particularly to agricultural interests in Imperial and San Diego Counties. Losses were estimated to be in excess of $25 million. Floodwaters destroyed 325 homes and businesses in the southern desert areas.

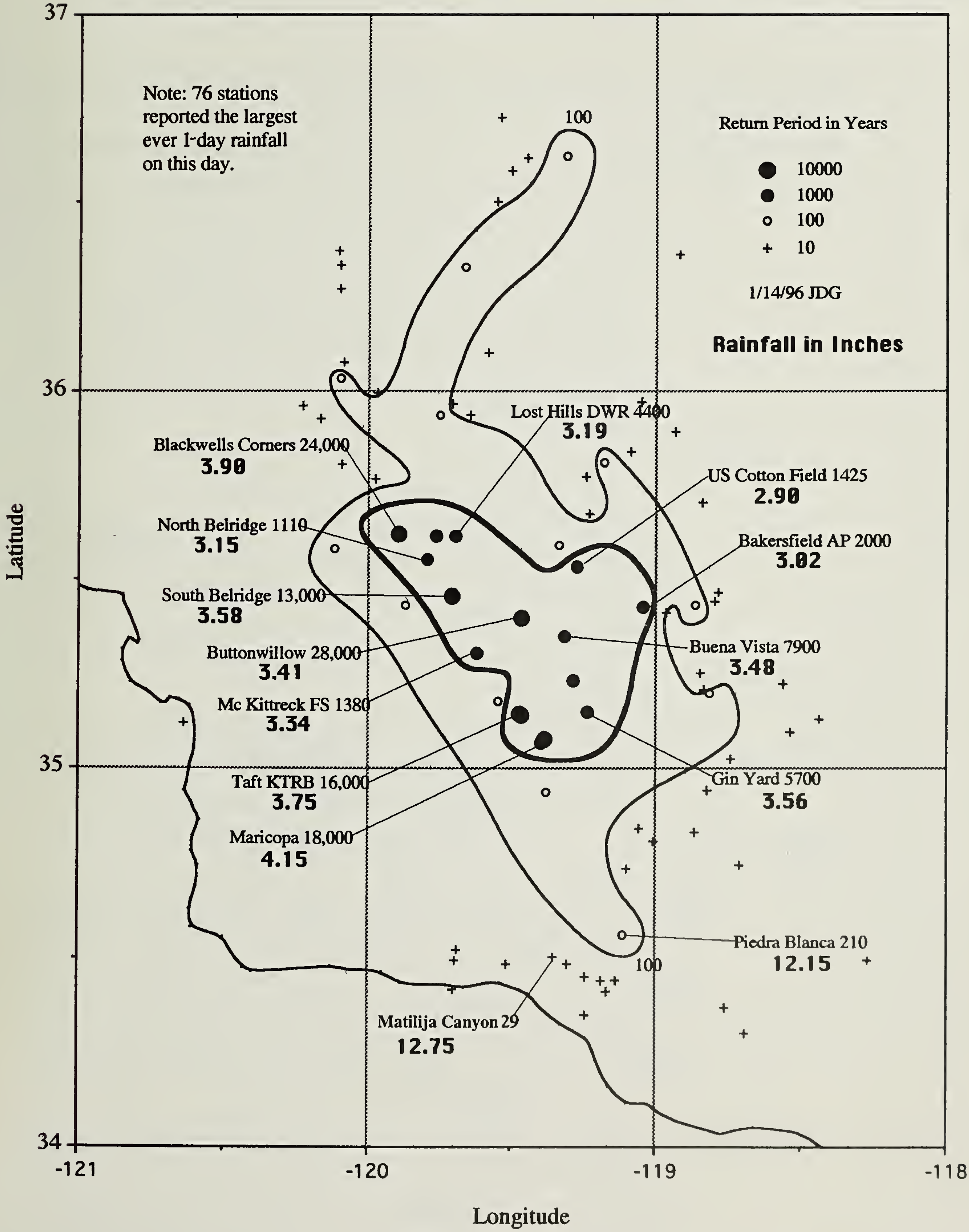
The heaviest rainfall was centered at Yuma Valley, Arizona. On August 16, 1977, 6.45 inches of rain occurred in one day. This storm was more than two times the mean annual precipitation of 2.88 inches for the 56 years of record. This was 10.83 standard deviations above the mean, with an estimate return period of 600,000 years.

Although Yuma Valley is located in Arizona, it is just across the Colorado River from California. The high rainfalls were also measured at the Yuma Citrus Station and the Brawley 2 SW station both of which experienced 1,000-year rainfalls. The largest ever rainfalls were experienced as far north as Thousand Palms, Hayfield Pump, Mecca, and Thermal. Sixteen stations reported the highest ever one-day rainfall.

Storm of February 10, 1978 (Map 23 on page 61)

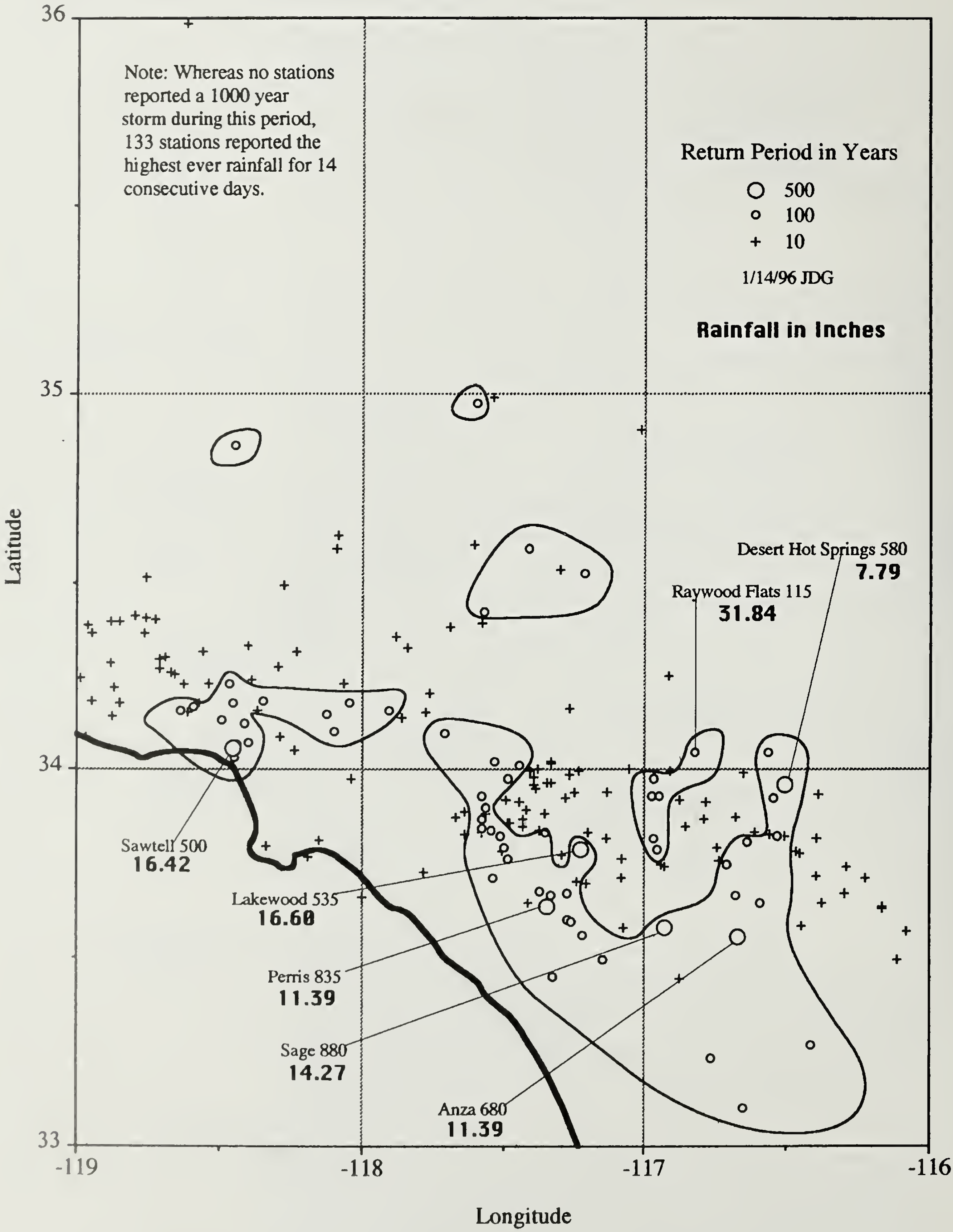
A vigorous winter cyclonic storm with widespread flooding and mud slides developed on the windward slopes of the south coastal basin. This storm was still quite robust as it moved into the comparatively dry San Joaquin Valley. This storm resulted in 18 deaths and $120 million in storm-related damages.

This storm resembles the tropical storm which came onshore near Santa Cruz in September 1918. Both storms vigorously entered the rain shadow areas to the northeast, resulting in a deluge in normally dry areas. This is



Note: 76 stations reported the largest ever 1-day rainfall on this day.
Return Period in Years
10000
1000
100
10
1/14/96 JDG
Rainfall in Inches
100
Lost Hills DWR 4400
3.19
Blackwells Corners 24,000
3.90
US Cotton Field 1425
2.90
North Belridge 1110
3.15
Bakersfield AP 2000
3.02
South Belridge 13,000
3.58
Buttonwillow 28,000
3.41
Buena Vista 7900
3.48
Mc Kittreck FS 1380
3.34
Taft KTRB 16,000
3.75
Gin Yard 5700
3.56
Maricopa 18,000
4.15
Piedra Blanca 210
12.15
100
Matilija Canyon 29
12.75
37
36
35
34
-121
-120
-119
-118
Latitude
Longitude

Map 24 Storm of February 14-21, 1980



another case of the many energetic cyclonic storms moving into a "rain shadow" area as it dissipates.

The storm, based on return period, was centered in the Buena Vista Lake region of Kern County. Blackwells Corner received 3.90 inches, 74 percent of the mean annual precipitation and 7.41 standard deviations above the mean maximum day. The associated return period was 28,000 years. Maricopa received 4.15 inches, which was 68 percent of the mean annual precipitation and 7.11 standard deviations above the mean. The average rainfalls in the region of 1,000-year rainfalls was only 3.48 inches. Seventy-six stations in this study experienced the highest ever daily rainfalls. Sixteen stations reported return periods in excess of 1,000 years and 32 stations reported return periods in excess of 100 years.

The highest rainfall depth of this storm was at Matilija Canyon in Ventura County, southwest of Buena Vista Lake Basin, where 13.31 inches was reported. Seven stations reported over 10 inches of rainfall. Matilija Canyon receives seven times more rain, or about 35 inches, in an average year than Buena Lake Basin. A rainfall of 13.31 inches in one day at Matilija Canyon has a return period of less than 30 years.

As a result of thorough soaking at an optimum time of year, the San Joaquin Valley was covered with a glorious profusion of wild flowers by mid-March. The meteorological aspects of this storm have been reported by Garza and Peterson.[38]

Storm of February 14-21, 1980 (Map 24 on page 62)
Disastrous and record-breaking rainfalls, centered in urban Orange County, resulted in the greatest ever rainfall totals over a broad area. Seven counties were declared disaster areas. Eighteen storm-related deaths occurred along with $270 million in property damage, and over 1,500 homes were damaged or destroyed.[38]

The greatest rainfall depth of this study was 31.84 inches at Raywood Flats in Riverside County. The return period at Raywood Flats for this storm was 115 years. The greatest return period for this storm study is at Sage in Riverside County, with 4.84 standard deviations over the mean

eight-day storm, which resulted in a 800-year return period. Record-high rainfalls for eight days occurred at 133 stations. Return periods in excess of 100 years were reported at 70 stations.

Storm of December 3, 1980

There were few indicators of the big storm that occurred at Ferguson Ranch located about 20 miles northwest of Red Bluff in Tehama County. The detailed hourly rainfall distribution was published in *Hourly Precipitation Data*, but few other stations reported an exceptional rainfall.[8]

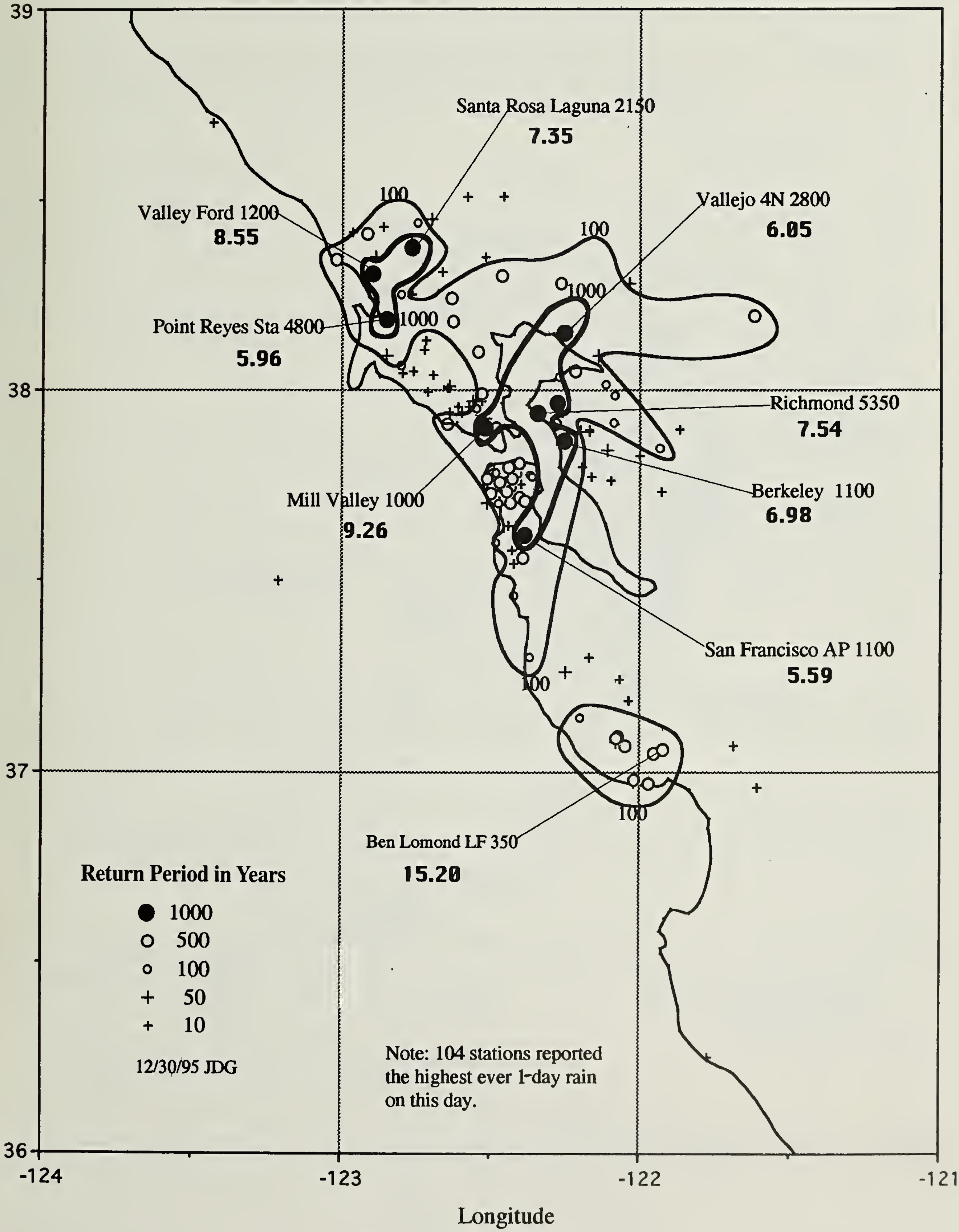
The U. S. Geological Survey streamflow records for Antelope, Elder, and Thomes Creeks did respond with a sharp rise in flow. The Shasta Dam rain gage caught 8.48 inches and the Whiskeytown gage caught 9.89 inches. The return periods at Shasta Dam and Whiskeytown were both less than 50 years. The Ferguson Ranch gage caught 12.00 inches, which was 8.72 standard deviations above the mean for an estimate return period of about 500,000 years.

This storm was probably similar in geographical distribution to the Newton storm of September 18, 1959, where 10.6 inches occurred in 5 hours.[26] Newton is located between Redding and Shasta Dam. Both were very severe storms covering a small area.

Storm of January 4, 1982 (Map 25 on page 65)

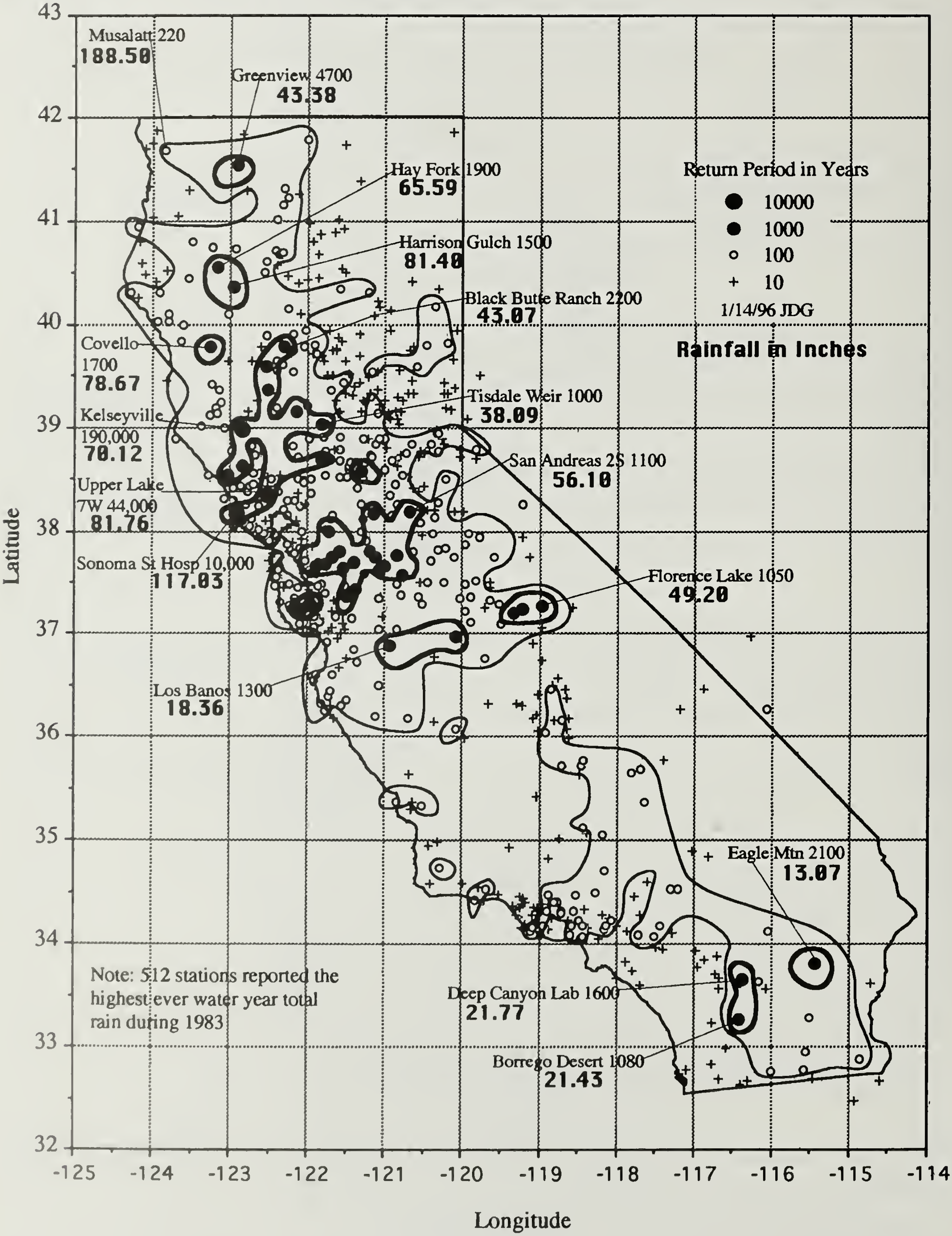
High winds, death, and devastation visited the San Francisco Bay area in the largest 24-hour rainfall recorded in the central California coast. At the Ben Lomond landfill, 15.20 inches of rain saturated the soil and caused landslides in Love Creek about 200 yards to the northwest of the Ben Lomond Landfill rain gage, as well as in Marin County. This was the greatest 24-hour rainfall in the central California coast. Seventeen stations in Marin and Santa Cruz Counties reported 10 inches in one day. Ten inches per day generally occur every 10 to 15 years in Ben Lomond and every 25 years at Kentfield.

One-quarter of the average annual rainfall occurred at 43 stations on this day. The San Francisco Airport recorded 30 percent of the mean annual precipitations during this storm. Berkeley had 6.98 inches of



Santa Rosa Laguna 2150
7.35
Valley Ford 1200
8.55
Vallejo 4N 2800
6.05
Point Reyes Sta 4800
5.96
Richmond 5350
7.54
Mill Valley 1000
9.26
Berkeley 1100
6.98
San Francisco AP 1100
5.59
Ben Lomond LF 350
15.20
100
1000
Return Period in Years
1000
500
100
50
10
12/30/95 JDG
Note: 104 stations reported the highest ever 1-day rain on this day.
Latitude
39
38
37
36
Longitude
-124
-123
-122
-121

Map 26 Rainfall for Wet Year of 1983



rainfall, exceeding the previous one-day record of 4.75 inches recorded in 1904. The return period for Berkeley was 1,100 years. Five other stations reported 1,000-year storms, the highest being 5,400 years at Richmond City Hall. Ten rainfall stations reported return periods of 500 years or more. There were about 1,100 square miles in the area exceeding the once-in-a-hundred-year rainfall.

In terms of return period, this was not one of the largest storms of California. This storm is important because it occurred in heavily populated areas. Twenty people were killed in landslides caused by the soaking rains, and $156 million in damages was reported.

Wet Year of 1983 (Map 26 on page 66)

New record-high annual total rainfalls were reported statewide for the 1983 water year. California received a long sequence of storms which left poorly drained areas soaked for many months. This resulted in unusually extensive flooding in areas like the Colusa Basin. In all regions, the high rainfall totals were associated with an increase in number of rainy days, rather than by large individual rainfalls.

Before 1983, the last year with rainfall this high was 1890. This is based on comparison of 75 continuous records from 1883. One hundred eleven years of annual rainfall averages in California are plotted on Figure 1 on page 3. The 1983 year was even more unusual in that 1982 was also one of the wettest years on record. Fifty-eight of the 705 stations studied in great detail for this storm reported 100 inches or more for water year 1983. At most of these stations, this was the wettest year ever.

It was also the year with the greatest rainfall for Sacramento since 1850. Sacramento had 96 days with rainfall in 1983. Normally, Sacramento has 58 days per year with rainfall.

The greatest rainfalls for 1983 ranged from 188.50 inches at Musalatt on the South Fork of the Smith River in the northwest corner of California to 173.37 inches at Mining Ridge in Monterey County. Although this is 1.8 times the mean annual precipitation for Musalatt, it is less than the State record of 257.90 inches at Camp Six, also in the Smith River Drainage, in the 1981-82 water year.

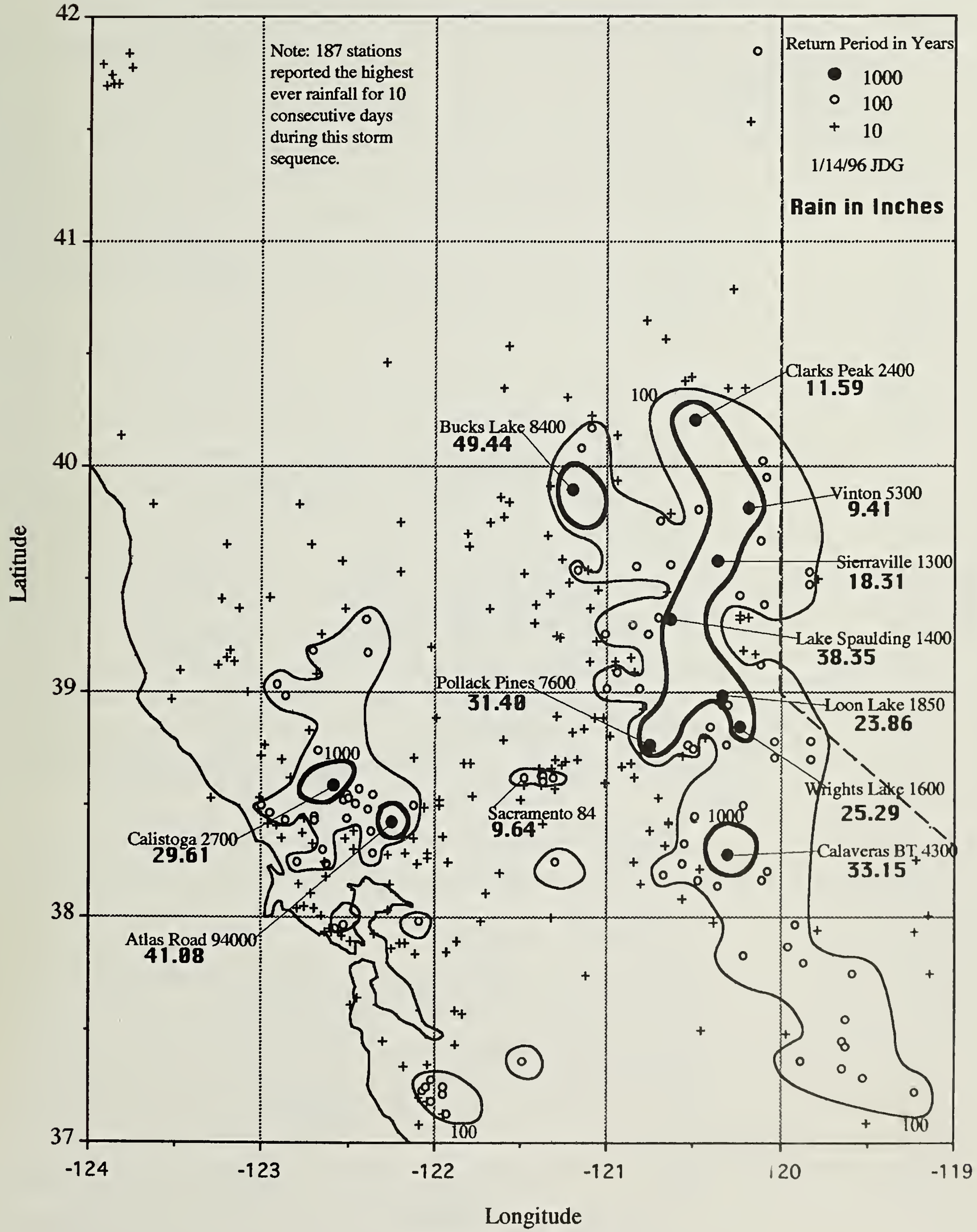
Forty-four stations reported annual total rainfalls in excess of the calculated once-in-a-thousand-year amounts during 1983. These were distributed from the Klamath River Basin in the north to the Borrego Desert in the south. Half of the State's land area had rainfalls in excess of the once-in-a-hundred-year rainfall during water year 1983.

Storm of February 11-20, 1986 (Map 27 on page 69)
A series of warm storms soaked the higher elevations of Central California. Widespread drenching rains in Central California led to extensive flooding and mud slides. Flooding resulted in 13 deaths, 50,000 evacuations, and over $400 million in property damage. This was the storm associated with the levee failure on the Yuba River at Linda, across the River south of Marysville.

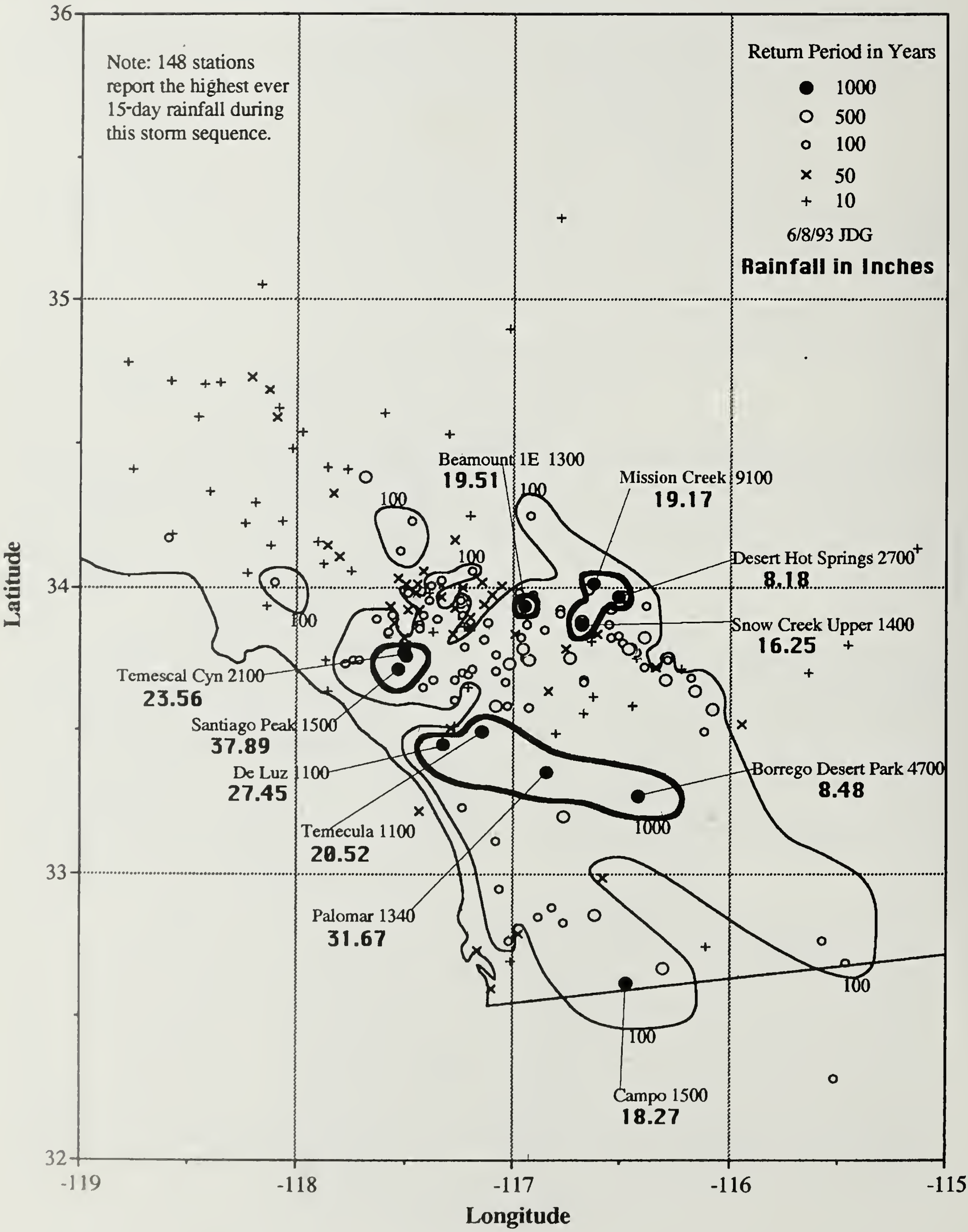
Stations in the central northern Sierra Nevada reported 50 percent of mean annual precipitation; Mono Lake reported 95 percent of mean annual precipitation in 10 days. Bucks Lake in the Feather River Basin recorded 49.44 inches, 71 percent of mean annual precipitation, during this storm.

In the Sierra Nevada, the storm affected mainly the area from Yosemite in the south to the Feather River Basin in the north. The stations receiving 1,000-year rainfalls ranged in a band from Clarks Peak, north of Sierra Valley in the Feather River Basin, to Calaveras Big Trees in the Cosumnes River Basin. Four Trees, near Bucks Lake, had 17.6 inches on February 17, 1986, the highest 24-hour rainfall ever recorded in the Central Valley.

Five hundred twelve stations reported the greatest rainfall for 10 days. Extensive flooding occurred in the Napa Valley and adjacent Russian River. Calistoga, in the Napa River Basin, had 29.61 inches, a return period of 2,600 years. The previous 10-day high rainfall at Calistoga was 20.00 inches in 1906. Rainfalls on the Russian River were heaviest on the southern end of the watershed. In reference to Guerneville, one newspaper reported that the town had just drowned. The return period for the 10-day storm at Ukiah in the north end of the Russian River was 31 years; at Graton it was 170 years.


Note: 187 stations reported the highest ever rainfall for 10 consecutive days during this storm sequence.
Return Period in Years
1000
100
10
1/14/96 JDG
Rain in Inches
Clarks Peak 2400
11.59
Bucks Lake 8400
49.44
Vinton 5300
9.41
Sierraville 1300
18.31
Lake Spaulding 1400
38.35
Pollack Pines 7600
31.40
Loon Lake 1850
23.86
Wrights Lake 1600
25.29
Sacramento 84
9.64
Calistoga 2700
29.61
Calaveras BT 4300
33.15
Atlas Road 94000
41.08
1000
100
Latitude
Longitude
42
41
40
39
38
37
-124
-123
-122
-121
120
-119

Map 28 Storm of January 5-19, 1993



Out of ten reports of over 10 inches of rainfall on February 17, most were in the Yuba, Bear, and American River Basins. Two were near the Napa River Basin and one was on the Smith River in the northwest corner of the State.

The Atlas Road telemetered rain gage on the north slope of Atlas Peak reported 41.08 inches of rainfall in 10 days. This is 7.4 standard deviations above the mean, or 113 percent of the mean annual precipitation. Streams draining on the east side of Atlas Peak experienced debris flow from streambeds stripped of vegetation. Large boulders lined the streambeds after the flood. Interstate Highway 80 was flooded downstream at Cordelia Junction.

Storm of December 1, 1987

La Porte, located in the Feather River Basin, received 12.84 inches of rainfall on this day. La Porte is situated at an elevation of 5,000 feet. It had a rain period of record from 1898 to 1933 where the average daily maximum for each year was 4.21 inches. The 12.84 inches is 5.82 standard deviations above the mean with a return period of 5,300 years.

Storm of January 17, 1988

This intense storm passed through California with high winds and surf. A 7-foot tide, combined with a 15- to 20-foot surf, caused an estimated $50 million damage to the Southern California coast.[39] Tornadoes were reported in Orange County. Several deaths occurred as a result of people becoming unexpectedly snowbound in the mountains of Southern California.

Rain was reported statewide, but only a few stations reported 4 inches of rainfall in 24 hours. Turlock reported 1.10 inches; Modesto reported 1.69 inches.

Newman reported 4.10 inches. Newman's 92-year mean annual precipitation is 10.27 inches. This represents a return period of about 20,000 years. The 4.10 inches at Newman is 6.67 standard deviations above the mean annual extreme storm. A local thunderstorm was probably embedded in the larger statewide storm that hit Newman on this day.

Storm of January 5-19, 1993 (Map 28 on page 70)

An energetic series of storms, associated with high wind and tornadoes, swept through Southern California. Extensive flooding resulted in the loss of

ten lives in January 1993.[39]

The high rainfalls of this storm were mainly from the high elevation locations on the windward slopes of the coastal ranges. An exception is that robust storm cells spilled over into the leeward or rain shadow areas of the desert resulting in record-breaking rainfalls in the low elevations of the desert near Palm Springs. In the southern coastal mountains, this storm left a rainfall pattern similar to the January 14-28, 1916, and February 13-17, 1927, storms.

Rainfall depths of over 30 inches were recorded at Palomar Mountain and stations as far north as Lake Arrowhead in the San Bernardino Mountains.

The greatest rainfall for this storm was at Santiago Peak located between Orange County and Riverside County at an elevation of 5,600 feet, where 37.89 inches were measured. The Santiago Peak storm was the greatest 15-day rainfall ever recorded there; it has a return period of 1,500 years. The Santiago Peak storm produced 116 percent of the average annual rainfall during this storm.

The largest return period for this storm was 3,200 years for Mission Creek, located near Desert Hot Springs in the Salton Sea drainage basin. Mission Creek received 19.17 inches of rain. This location typically receives 11.68 inches of rain annually.

Seventy-one stations recorded 15-day rainfall totals which equaled or exceeded the average annual rainfall. The greatest 15-day rainfall totals of record occurred at 132 stations during this storm. Ten stations reported 1,000-year rainfall totals.

The data set on which this study is based is mainly the National Weather Service stations as reported in *Climatological Data*.[2] Additional data came from Riverside County Flood Control and Water Conservation District and Orange County Water Agency. There are many additional rain records which will be analyzed for future versions of this study. The picture of this storm will evolve further as more data are added. Another aspect that leads to changes is finding and correcting errors, which is a continuing process.

Climatic Variation

Climatic variation or fluctuation as studied here refers to two data sets. The first is a tabulation of the mean annual precipitation at 75 stations with data compiled for the period 1883 to 1995 (Figure 1 on page 3). The second is a tabulation of average maximum daily precipitation at 92 stations for the period 1904 to 1995 (Figure 3 on page 77).

Mean Annual Precipitation

In this report, the mean annual precipitation refers to the average of the total water-year precipitation for the 111 years from 1883 to 1995.

The average maximum daily precipitation refers to the average of the water-year extreme highest precipitation for the period 1904 to 1995.

The mean annual precipitation at 76 stations for 113 years is 22.95 inches, comparable to the average of 200 million acre-feet of average annual precipitation for the State, as used in other studies. The annual precipitation values shown on Figure 1 should be a fairly useful model for the State's precipitation variability. The outstanding features of Figure 1 are the four high years of 1890, 1941, 1983, and 1995 as well as the two low years of 1924 and 1977. Total rainfall for the 1982-83 water year resulted in record high rainfalls over a large portion of California ranging from Siskiyou to San Diego Counties. Over 500 stations reported the greatest water year total rainfall of record (Map 26 on page 66).

The variability in the annual total rainfall was measured using the coefficient of variation (CV). CV is the ratio of the standard deviation over the average. CV was calculated for running 10-year periods from 1883 to 1995. A long-term increase in the variation in annual rainfall for California is shown on Figure 4 on page 78. The relative variation in water year total rainfall has been greater in the last decade than at any other time in the last 113 years.

The average of the annual maximum daily rainfall for 92 stations from 1904 to 1995 is used as an index of variation in flood producing rainfalls (Figure 3). Some of these records were not complete. A few of the stations had as much as 5 percent estimated annual maximum rainfall.

In the long-term, there is no trend in the mean annual precipitation of the composite sample shown in Figure 1. This lack of trend is also reflected in the daily maximum precipitation as shown in Figure 3. When these data sets were decomposed into individual elements, a regional pattern emerged.

Figure 5 (on page 79) is a plot of the 100-year annual rainfall trend at individual stations. Figure 6 (on page 80) is a plot of the regional variation in the annual maximum daily rainfall at 92 locations for the period 1904 to 1995. There is a long-term drying trend in much of California. This is shown on Figure 5 (on page 79) for the average annual rainfall trend and on Figure 6 (page 80) for the trend in the average maximum daily rainfall.

There is an increase in total yearly rainfall in the interior stations for the 100 years. The trend at 96 stations with 100 years of rainfall record is shown on Figure 5. The individual records of maximum daily rainfall were normalized to see a pattern of drier coast area and wetter interior area as shown on Figure 6. The units are in "departure from the mean," rather than in inches.

The cause of the increased rainfall in interior California can be attributed to long-term climatic variation or fluctuation. It could also be due, in part, to inadvertent weather modification caused by an increase in atmospheric particulates discharged into the air by human activity upwind. An understanding of this variation will require further study.

The records of the maximum daily rainfalls were averaged by five climatic divisions for California as used in *Climatological Data*.[2] There are seven climatic divisions; the northeast interior and the southeast desert were not studied for climatic variability due to lack of records.

North Coast

The average maximum daily rainfalls for the north coast for each year is plotted on Figure 7 (on page 81), along with a linear trend line and a nine-year running average. This graph is based on 11 stations with data for the 92 years from 1904 to 1995. There is a slight increase in long-term trend in average maximum daily rainfall. The nine-year running average of the maximum daily rainfall in the north coast shows peak values in 1914 and in 1982, not unlike similar graphs for mean annual temperature data.

The years of greatest average daily rainfall in the north coast are 1904, 1914, 1982, and 1995. The great storm of 1964 (Map 20 on page 53) is

not expressed in this figure, indicating that the maximum one-day rainfall was not a good indicator of flooding from a storm that lasted eight days. The big rainfall of January 4, 1982, (Map 25 on page 65) affected mainly the Marin County area of the north coast region.

Sacramento Valley

There are east-west differences in the trends in maximum daily rainfall in the Sacramento Valley (Figure 8). There was a slight increase in long-term rainfall trend in the maximum daily rainfalls of the Sacramento Valley as a whole (Figure 8 on page 82). The rainfall records of the northern Sierra Nevada have a definite increase in maximum daily rainfall during the 40 years ending in 1995. This trend was based on the average of 23 rainfall records.

The decrease in the level of baseline flood protection at Sacramento from Folsom Dam, from over 100-year to a 60-year level on the American River, has reflected or reflects this climatic variation.

The big one-day storm of the Sacramento Valley was the Columbus Day storm of 1962 (Map 18 on page 49). There were two large rainfalls in water year 1963; many of the high-elevation stations of the American River Basin had the greatest rainfalls during the January 30 to February 1, 1963 storm (Map 19 on page 52). There were storms which produced larger individual rainfalls, but they covered a relatively small area compared with the very large Columbus Day Storm of 1962.

The largest ever one-day rainfall in the Central Valley was the 17.6 inches at Four Trees in the Feather River Basin on February 17, 1986. The greatest ever daily rainfall for Colusa and Chico was on January 3, 1916.

Central Coast

The long-term trend in maximum daily precipitation for the Central Coast area for the last 92 years is downward, based on a 19-station average for 1904 to 1995. The trend for the Central Coast is shown in Figure 9 on page 83.

The years with high average maximum daily rainfalls were in water years 1911, 1956, 1963, 1982, and 1995. The record storm of 1911 occurred on

January 13 in the San Jose area. New record-high rainfall totals were measured in late December 1955, resulting in the Christmas-time flood in the Santa Clara Valley. The next big event was the Columbus Day storm of 1962 in which millions of trees were uprooted by high winds on the Pacific Coast. The January 4, 1982 storm brought the greatest rainfalls north of Santa Cruz, resulting in the Love Creek landslide where many people lost their lives. The great Salinas River flood of March 10, 1995, is compared with other years in Figure 9.

San Joaquin Valley

There are east-west differences in the trends in maximum daily rainfall in the San Joaquin Valley (Figures 5 and 6), but only a slight increase in long-term trend in heavy daily rainfalls (Figure 10 on page 84). One feature of Figure 10 is that the March 10, 1995 storm near Coalinga is the only large rainfall since the Columbus Day Storm of 1962.

The outstanding storm of this area was on December 23, 1955 (Map 17). Florence Lake, located at 7,300 feet, in the southern Sierra Nevada had a record of 15.14 inches of rain in eight days. An outstanding low-elevation storm in the San Joaquin Valley was the February 10, 1978 storm. However, this storm occurred in a very low rainfall area and, therefore, was not a high-volume rainfall producer.

South Coast

The 92-year trend in maximum daily rainfall in the South Coast is downward. This indicates that the biggest rainfalls occurred in the early part of the record. There were no well-defined local differences in long-term trend. The declining trend in the maximum rainfalls of the South Coast area is shown on Figure 6 and Figure 11 (page 85). The earlier storms like 1916, 1938, and 1943 were larger as indexed here by 23 stations. The big storms of 1969, 1980, and 1993 affected a greater population of people; therefore, the more recent storms caused greater damages.

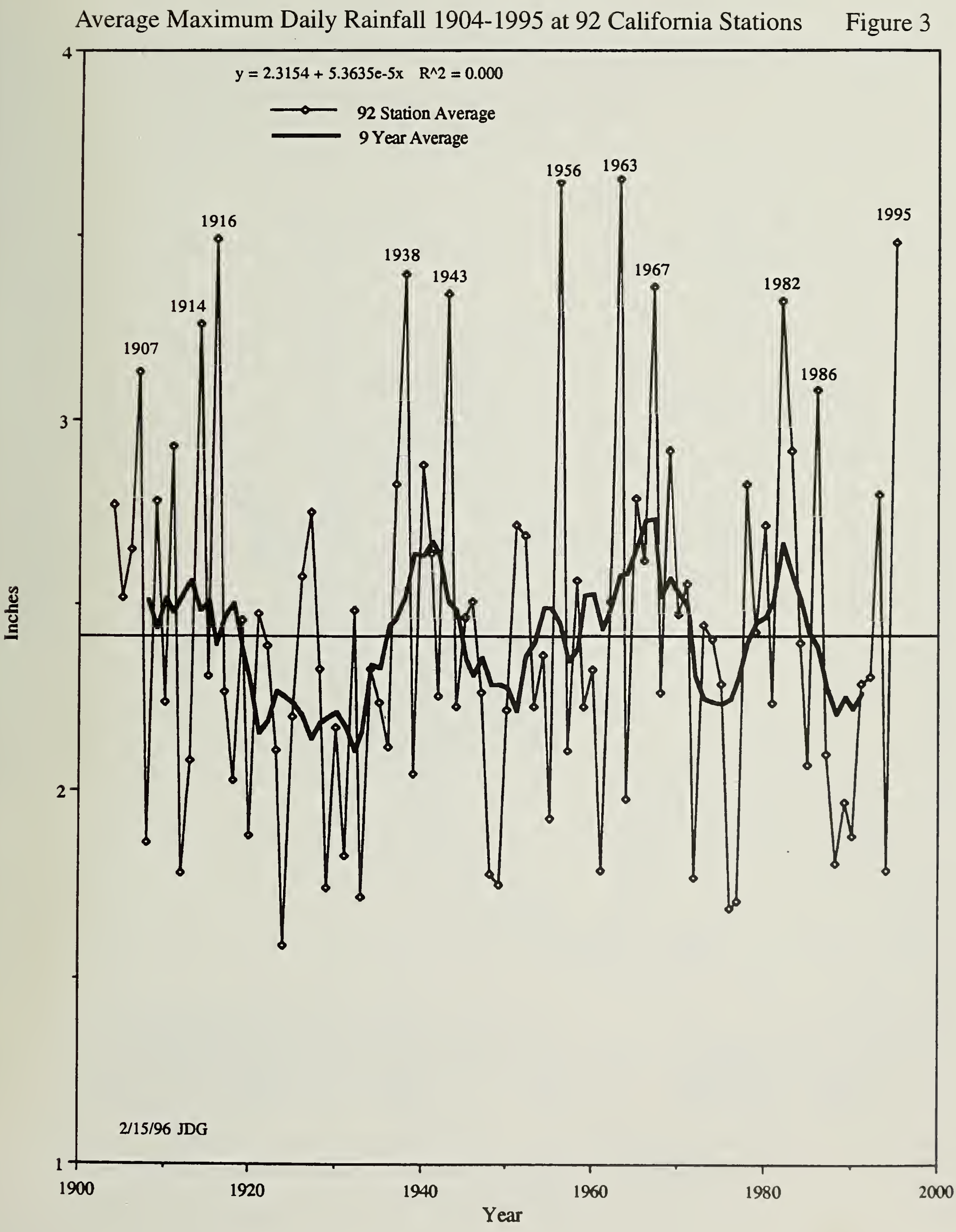
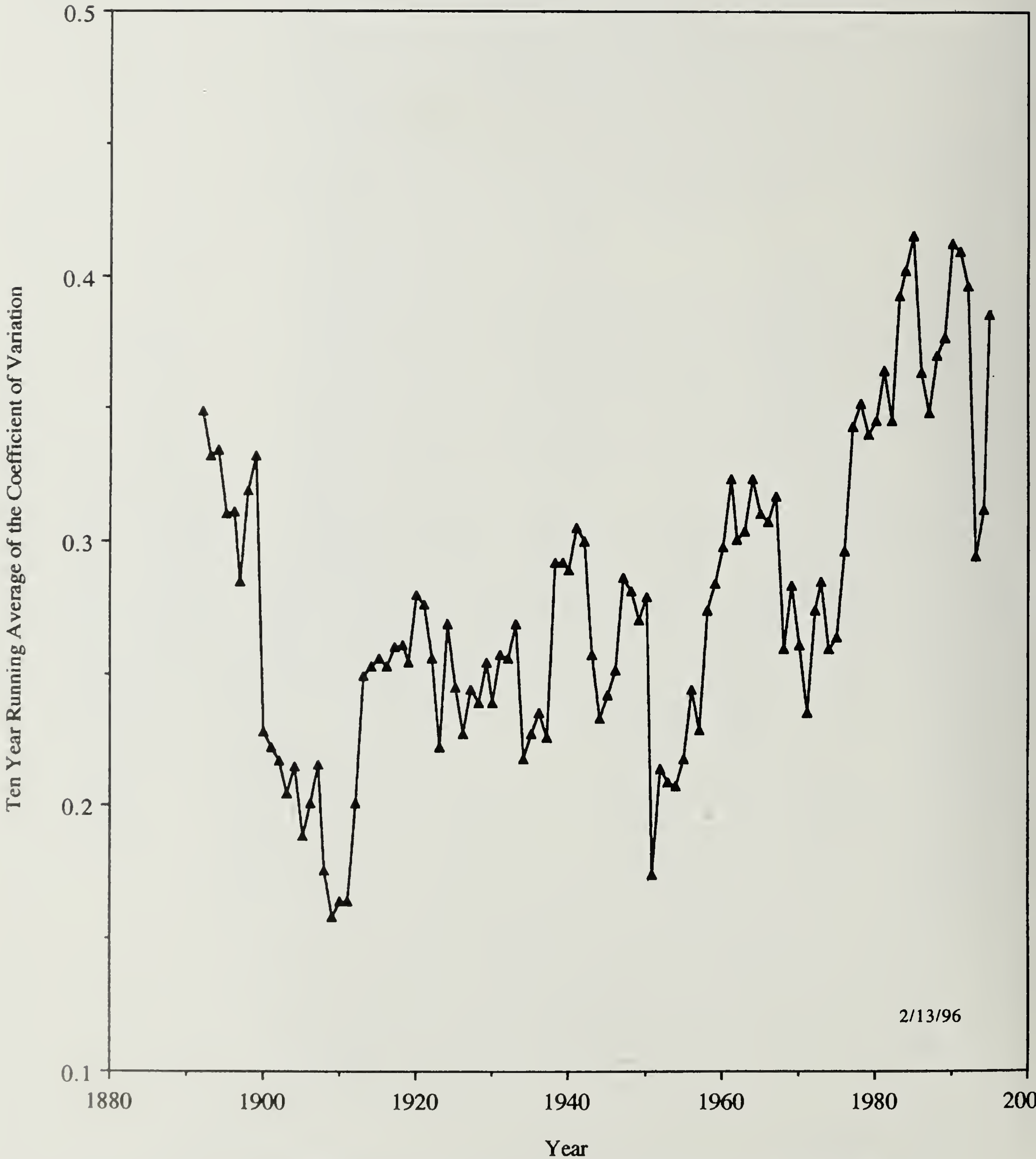

Average Maximum Daily Rainfall 1904-1995 at 92 California Stations
Figure 3
y = 2.3154 + 5.3635e-5x R^2 = 0.000
92 Station Average
9 Year Average
1907
1914
1916
1938
1943
1956
1963
1967
1982
1986
1995
2/15/96 JDG
Inches
Year
1
2
3
4
1900
1920
1940
1960
1980
2000

Figure 4 Variability of California Rainfall 1904-1995



The Coefficient of Variation is the ratio of the standard deviation over the average.

Based on 76 records of water year total rainfall which were complete for 1883 to 1995.

100 Years of California Rainfall Trends Figure 5

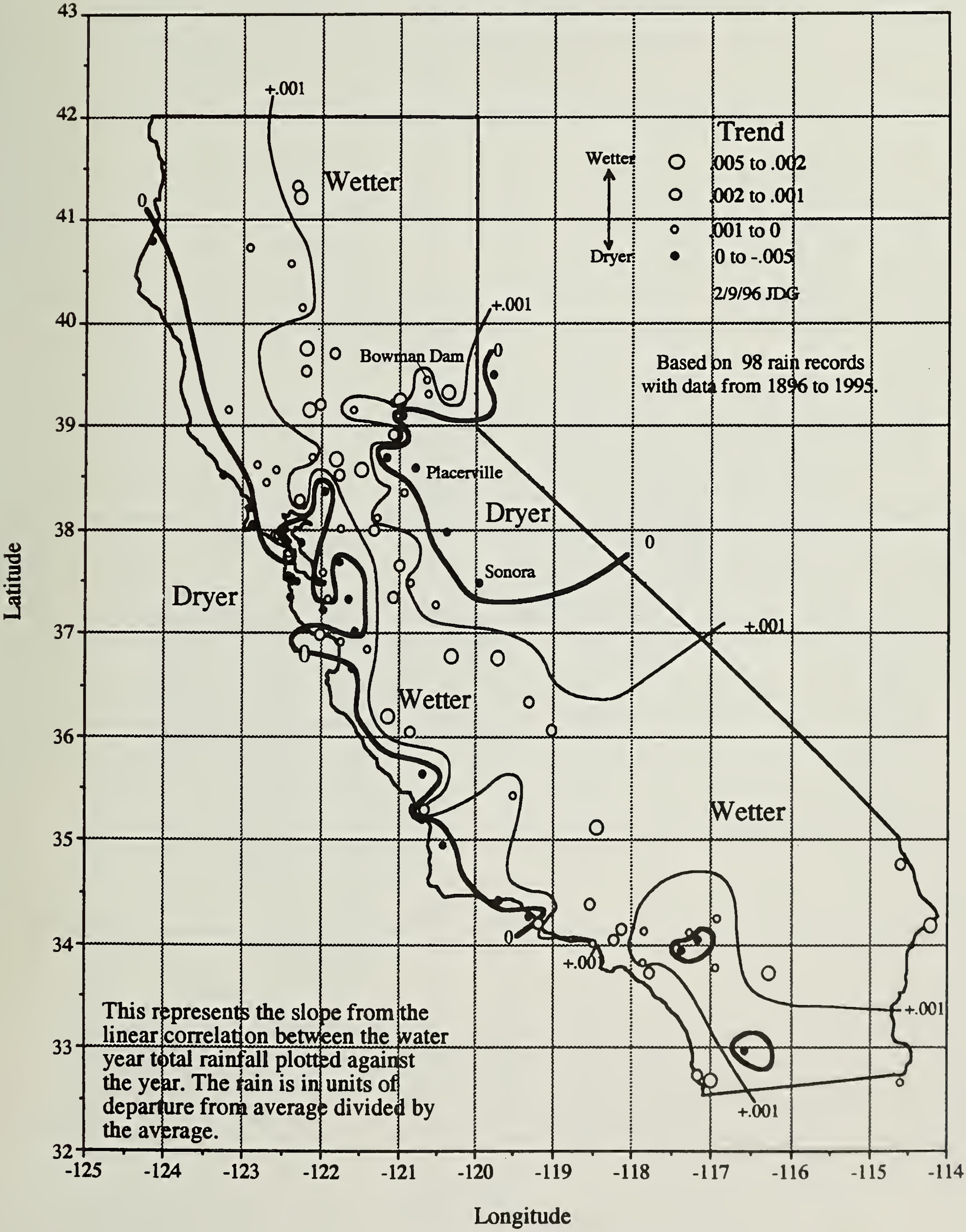
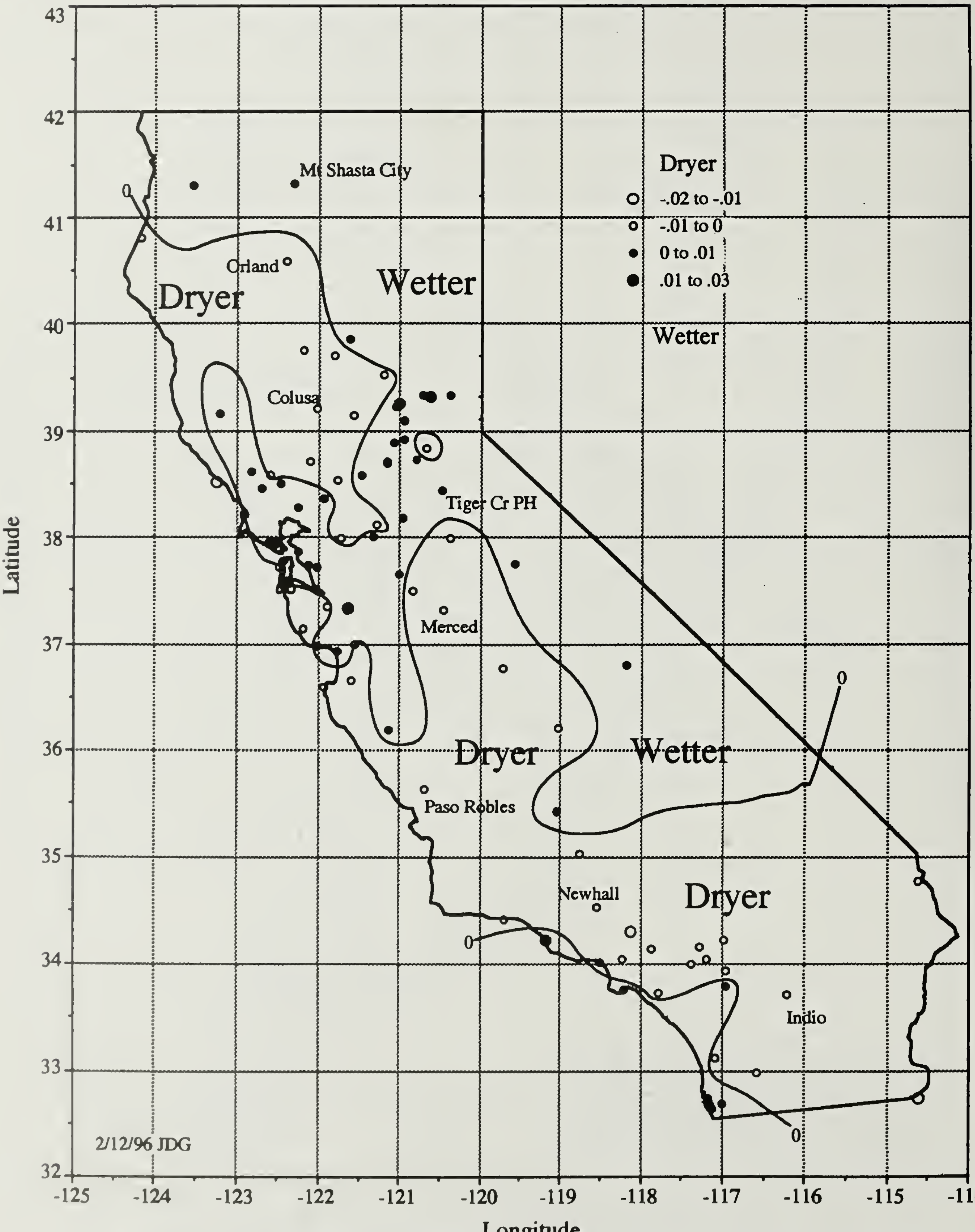


Figure 6 Trends in Flood-Producing Rainfalls in California



Based on a linear trend in maximum daily rainfall for 1904 to 1995 at 92 locations.

Maximum Daily Rainfall 1904-1995 in the North Coast Figure 7

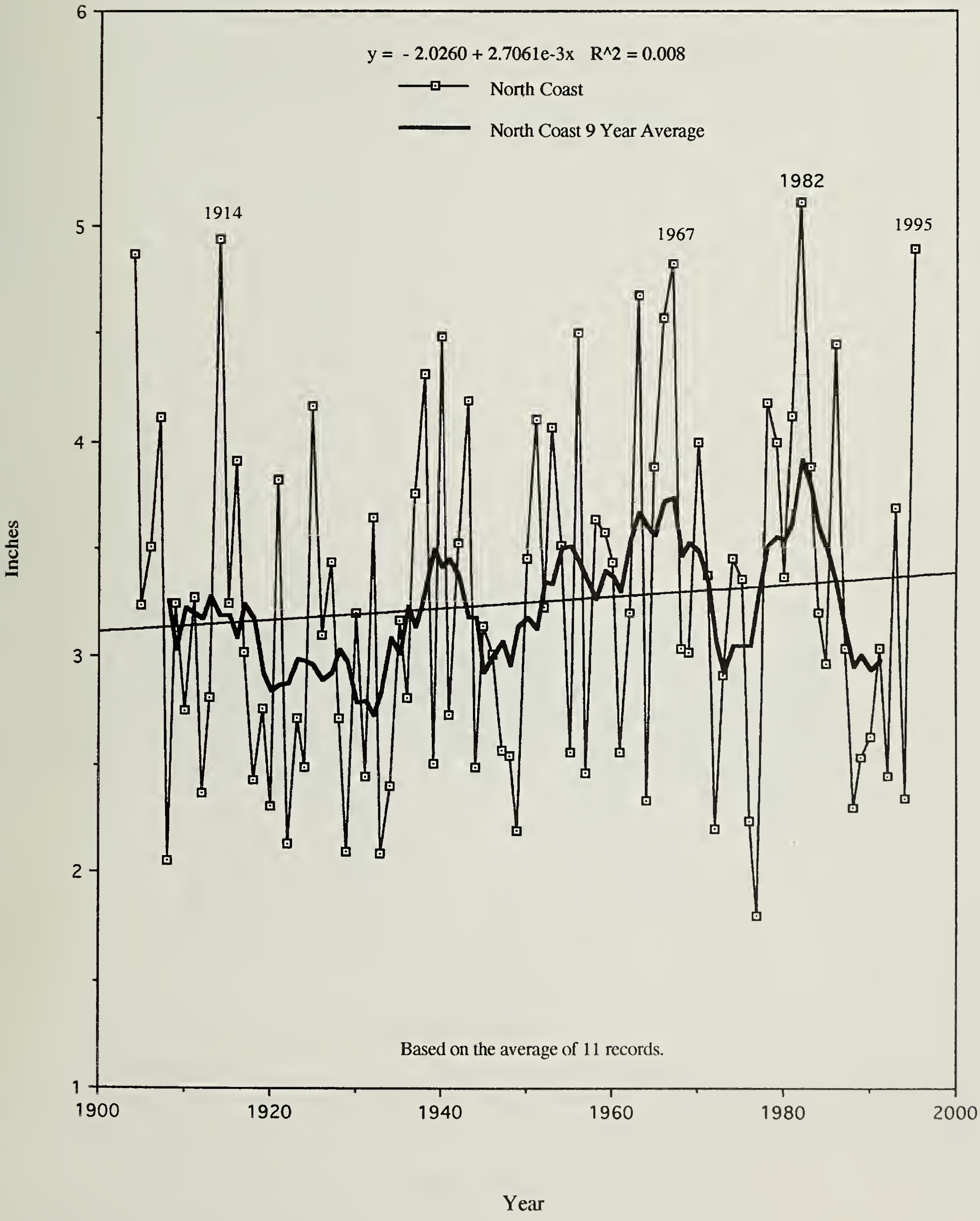
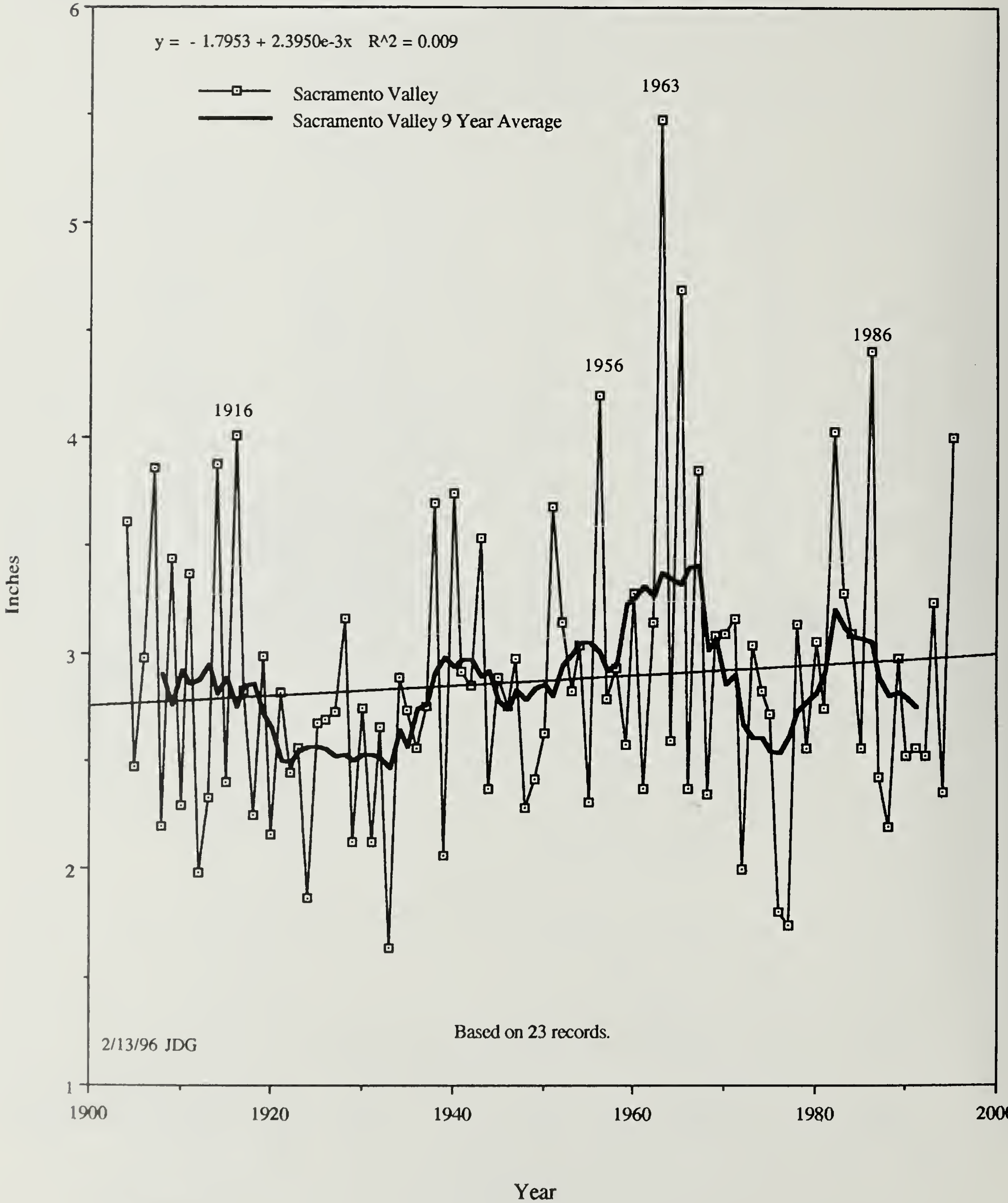


Figure 8 Maximum Daily Rainfall 1904-1995 in the Sacramento Valley



Maximum Daily Rainfall 1904-1995 in the Central Coast Figure 9

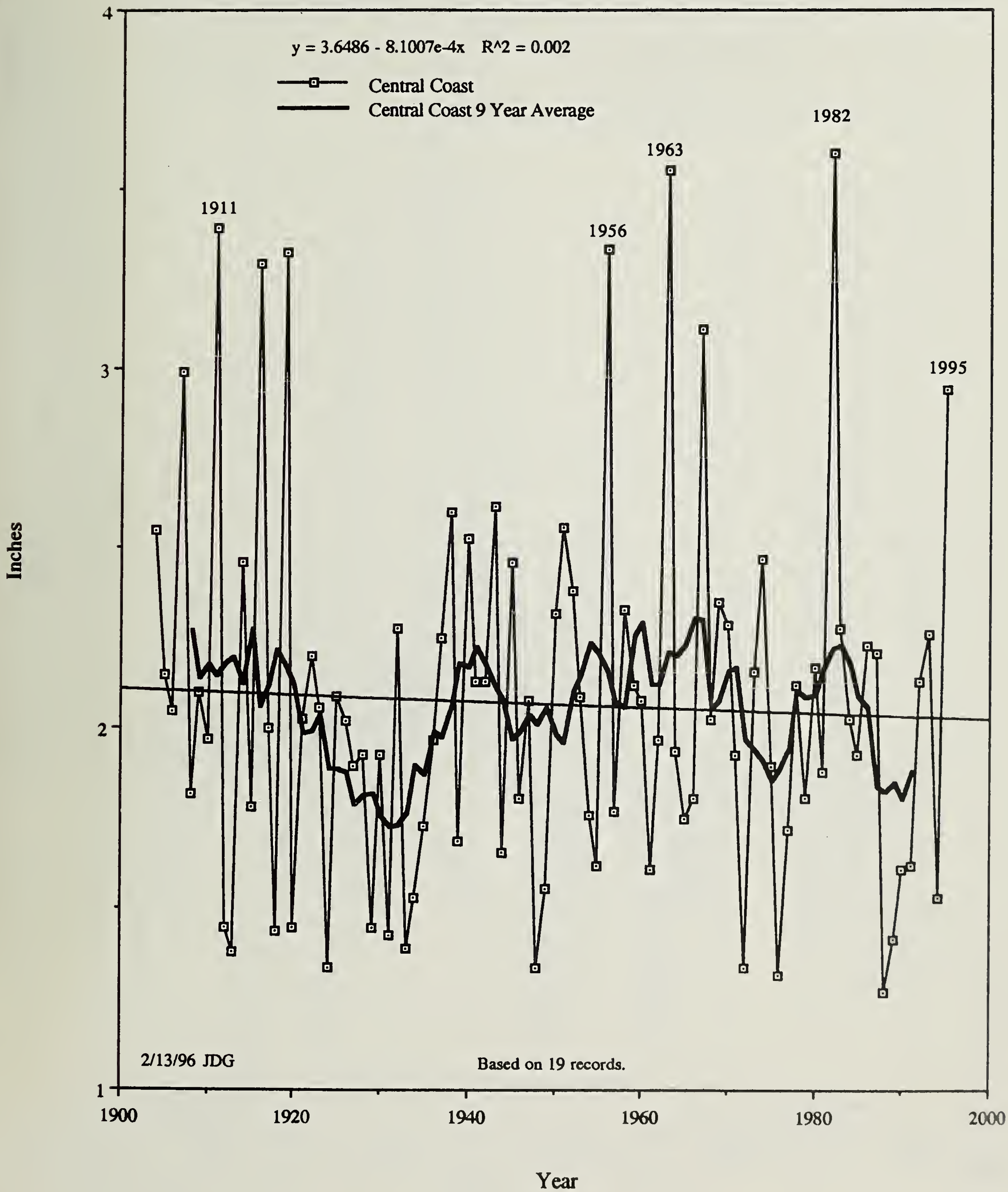
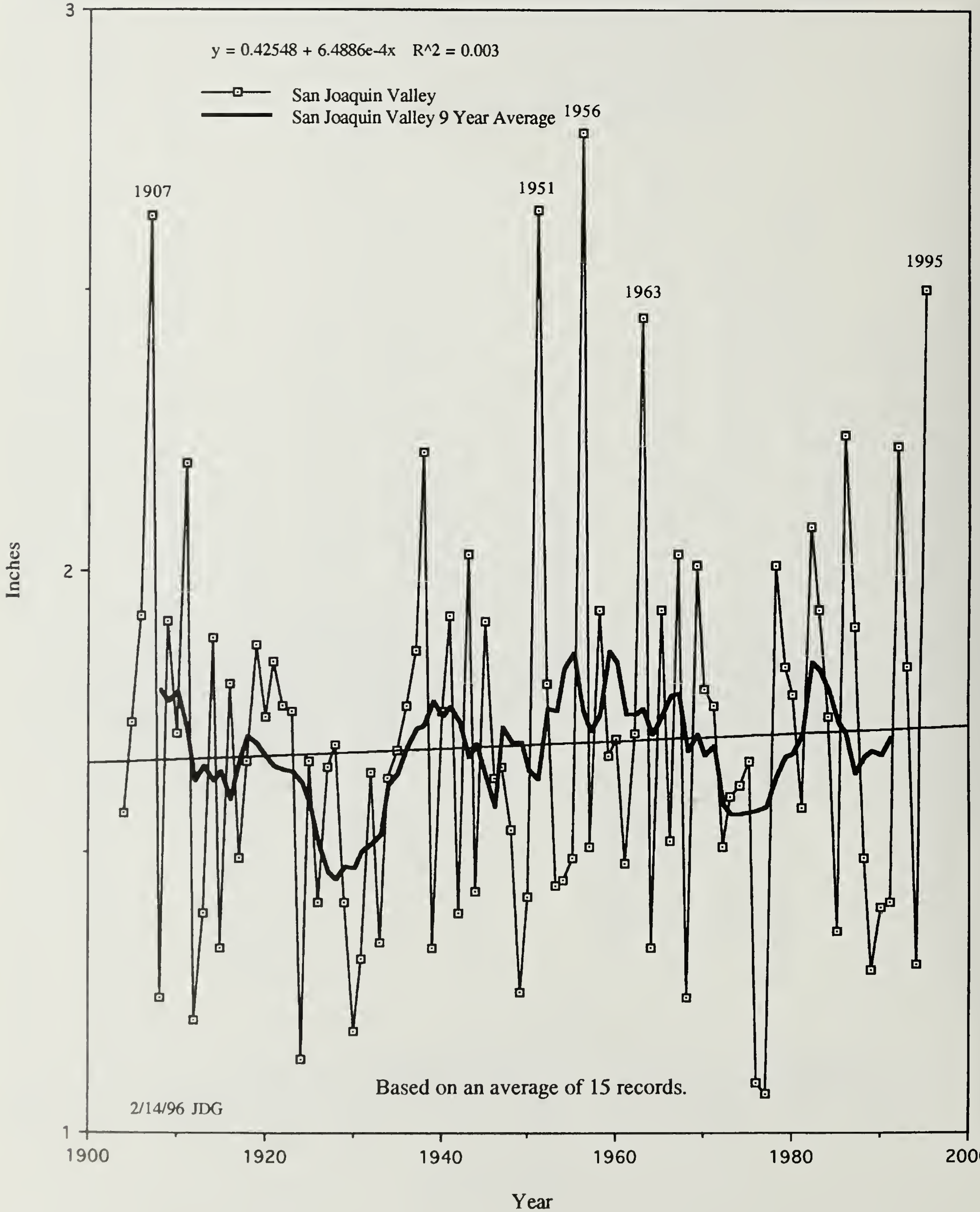
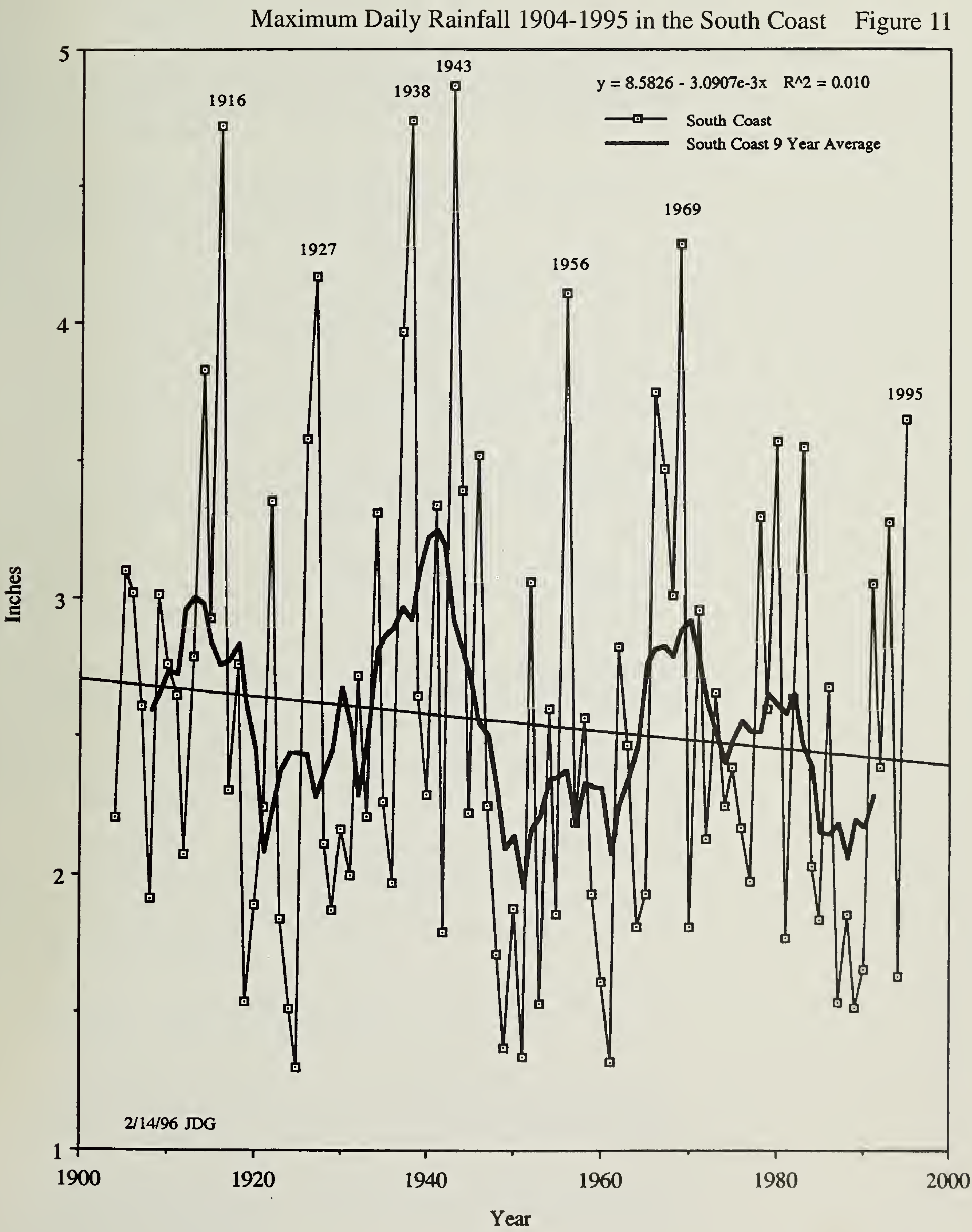


Figure 10 Maximum Daily Rainfall 1904-1995 in the San Joaquin Valley




Maximum Daily Rainfall 1904-1995 in the South Coast Figure 11
y = 8.5826 - 3.0907e-3x R^2 = 0.010
South Coast
South Coast 9 Year Average
1916
1927
1938
1943
1956
1969
1995
Inches
Year
1900
1920
1940
1960
1980
2000
1
2
3
4
5
2/14/96 JDG

Glossary

ALERT System Automated Local Evaluation in Real Time. The system of rainfall reporting in real time by automated rain gages for use in flood forecasting.

Annual Series The annual maximum data for each year. This is in contrast to Partial Duration Series which consists of the largest of record regardless of year of occurrence.

Annual extreme rainfall The greatest depth of rainfall during a water year. In this study it refers to maximum rainfall for 1,2,3,4,5,6,8,10,15,20,30, or 60 consecutive days.

Coefficient of Variation Ratio of the standard deviation divided by the average. See Frequency Distribution equation (sidebar, page 18).

Cyclonic storm A storm with the buildup of robust weather systems on the windward slopes, which occasionally spill over onto the "rain shadow zone" on the leeward side of the mountains.

Debris flow A flow of mud and rock similar to the consistency of freshly mixed concrete, which moves at high speed and causes extensive damage to streambeds.

Design standard deviation A working value or an estimate of the standard deviation; specifically, it is the product of the average rainfall times the approximate regional coefficient of variation.

Design storm An estimate of the rainfall for a specific return period and storm duration.

Frequency factor The number of standard deviations above the average for a specific return period. See Table 4 (page 114).

High elevation storm A storm that affects higher elevations rather than lower elevations.

Kurtosis The peakedness of an array of rainfall data. See Statistical Estimators equation (sidebar, page 18).

Mean Annual Precipitation The long-term average water year total rainfall for the entire period of record at a rainfall measuring station. The words "mean" and "average" are used interchangeably in this study.

Nonrecording rain gage A container used to make daily manual measurements of rainfall that does not include a device to automatically record the measurements.

Once-in-a-thousand-year storm A large storm that will reoccur on

the average of every thousand years. It is roughly the average event plus five standard deviations.

Outliers A large value which has a large influence on the sample statistics.

Orographic lifting The lifting of an air mass over a topographic ridge by wind.

Precipitation All water that falls due to gravity. It includes rain, drizzle from fog, melted water equivalent of snow, hail, and all forms of frozen precipitation.

Rainfall The amount of water falling from clouds as measured on a horizontal plane with vertical sides. In this study, the terms "rainfall" and "precipitation" are both used for precipitation.

Rainfall frequency The rainfall amount for a specific return period.

Rainfall records A diary recording the daily rainfall totals.

Rain Shadow The dry side of a mountain where rain is light. This is on the lee side where the air mass is descending and therefore heating.

Recording rain gage A device used to electronically or mechanically record the time of rainfall as well as the total amount.

Return period The average time in years between events.

Second feet Cubic feet per second.

Skew A measure of symmetry in an array of rainfall data. See Statistical Estimators equation on page 18.

Standard Deviation A measure of the deviation from the average. See Statistical Estimators equation on page 18.

Tropical cyclones In this study, a late summer or early fall cyclonic storm originating in a tropical region such as the west coast of Mexico. These storms commonly move north into California accompanied by heavy wind and rain or a surge of moisture in which thunderstorms develop.

Water year In this study, a water year is similar to that used by the United States Geological Survey for surface water records, specifically from October 1 to September 30. However, some agencies use other periods such as September 1 to August 31, July 1 to June 30, or the calendar year. The preferred is October 1 to September 30.

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Appendix

List of Stations for Study of Maximum Daily Rainfall

Station	County	Div	DA	Sta #	Longitude	Latitude	Elev.	Average	Rec Max
Calistoga	Napa	1	E30	1312	-122.583	38.585	364	3.63	9.14
Eureka	Humboldt	1	F60	2910	-124.167	40.800	43	2.35	5.04
Fort Ross	Sonoma	1	F80	3161	-123.250	38.517	116	3.37	8.81
Graton	Sonoma	1	F90	3577	-122.864	38.431	200	3.77	6.90
Healdsburg	Sonoma	1	F90	3875	-122.833	38.617	101	3.72	8.18
Kentfield	Marin	1	E20	4500	-122.551	37.946	80	4.54	11.56
Lagunitas	Marin	1	E10	4652	-122.595	37.940	785	4.14	9.15
Napa	Napa	1	E30	6065	-122.264	38.278	73	2.15	5.85
Orleans	Humboldt	1	F30	6508	-123.533	41.300	403	2.96	7.38
Santa Rosa	Sonoma	1	F90	7965	-122.700	38.450	167	2.71	5.62
St Helena	Napa	1	E30	7643	-122.461	38.507	255	3.31	7.00
Ukiah	Mendocino	1	F90	9125	-123.200	39.150	623	2.88	6.18
Auburn	Placer	2	A70	0373	-121.069	38.889	1292	2.64	5.41
Blue Canyon	Placer	2	A70	0897	-120.708	39.328	5280	4.15	9.33
Capay 4W	Yolo	2	A80	1500	-122.117	38.705	300	2.44	4.47
Chico	Butte	2	A00	1715	-121.817	39.700	185	2.22	5.73
Colfax	Placer	2	A70	1912	-120.952	39.099	2418	3.50	10.02
Colusa	Colusa	2	A00	1948	-122.017	39.200	60	1.59	5.60
Davis	Yolo	2	A00	2294	-121.775	38.535	60	1.84	3.93
DeSabla	Butte	2	A40	2402	-121.627	39.867	2720	4.61	11.70
Folsom	Sacramento	2	A70	3113	-121.161	38.707	350	1.99	4.16
Grass Valley	Nevada	2	A60	3571	-121.059	39.226	2693	4.03	8.10
Lake Spaulding	Nevada	2	A60	4713	-120.637	39.319	5153	4.63	11.55
Marysville	Yuba	2	A00	5385	-121.584	39.146	60	1.81	4.34
Mt Shasta	Siskiyou	2	A20	5983	-122.317	41.317	3544	2.83	7.83
Nevada City	Nevada	2	A60	6136	-121.011	39.258	2600	3.89	7.49
Orland	Glen	2	A00	6506	-122.200	39.750	254	1.93	4.28
Placerville	El Dorado	2	A70	6960	-120.798	38.729	1890	2.82	5.28
Quincy	Plumas	2	A50	7195	-120.950	38.917	3409	3.28	6.50
Redding	Shasta	2	A00	7276	-122.400	40.583	577	2.95	7.30
Represa	Sacramento	2	A70	7370	-121.161	38.693	295	1.98	4.54
Rockville	Solano	2	E30	7519	-122.095	38.239	40	2.14	4.68
Sacramento	Sacramento	2	A00	7633	-121.483	38.583	25	1.75	3.63
Soda Springs	Placer	2	A60	8332	-120.367	39.326	6885	3.67	10.60
Vacaville	Solano	2	A00	9200	-121.949	38.360	104	2.65	6.10
Willows	Glen	2	A00	9699	-121.200	39.530	140	1.88	4.70
Berkeley	Alameda	4	E40	0993	-122.250	37.867	299	2.21	6.98
Chabot Res	Alameda	4	E50	1648	-122.121	37.730	245	1.98	6.04
Crystal Sp Cott	San Mateo	4	E70	2205	-122.367	37.500	400	2.07	5.77

List of Stations for Study of Maximum Daily Rainfall

Station	County	Div	DA Sta #	Longitude	Latitude	Elev.	Average	Rec Max
Forest Lake	Monterey	4	D40 3135	-121.942	36.592	295	1.66	6.07
Gilroy	Santa Clara	4	D10 3417	-121.567	37.000	194	2.30	7.13
Jensen Ranch	Alameda	4	E40 4357	-122.023	37.713	850	2.19	6.10
King City	Monterey	4	D20 4555	-121.133	36.200	320	1.45	3.72
Lake Merced	San Francisco	4	E80 4691	-122.487	37.717	17	1.68	3.62
Lower Crystal Sp	San Mateo	4	E70 5156	-122.367	37.533	450	2.24	4.81
Mt Hamilton	Santa Clara	4	E50 5933	-121.650	37.333	4206	2.15	6.87
Oakland	Alameda	4	E40 6335	-122.200	37.133	3	1.88	4.74
Paso Robles	San Luis Obispo	4	T09 6730	-120.683	35.633	700	1.89	5.25
Pilarcitos	San Mateo	4	E80 6863	-122.421	37.547	625	3.10	6.50
Salinas	Monterey	4	D20 7669	-121.600	36.667	80	1.34	3.12
San Andreas L	San Mateo	4	E70 7704	-122.400	37.583	377	2.65	6.20
San Francisco	San Francisco	4	E70 7772	-122.417	37.783	52	1.86	5.54
San Jose	Santa Clara	4	E60 7821	-121.903	37.342	95	1.63	4.55
Santa Cruz	Santa Cruz	4	D00 7916	-122.017	36.983	125	2.72	6.91
Upper Crystal Sp	San Mateo	4	E70 9163	-122.350	37.500	300	2.20	4.32
Watsonville	Santa Cruz	4	D10 9473	-121.767	36.933	95	2.21	5.90
Antioch	Contra Costa	5	B80 0232	-121.728	37.984	60	1.37	3.88
Bakersfield	Kern	5	C00 0439	-119.043	35.427	494	0.86	2.70
Electra	Amador	5	B20 2728	-120.667	38.838	715	2.38	4.83
Fresno	Fresno	5	C00 3257	-119.717	36.770	331	1.15	2.38
Lemon Cove	Tulare	5	C20 4890	-119.025	36.217	513	1.57	3.66
Lodi	San Joaquin	5	B00 5032	-121.289	38.116	40	1.63	3.76
Merced	Merced	5	B00 5535	-120.470	37.315	168	1.21	2.69
Modesto	Stanislaus	5	B00 5738	-121.001	37.647	91	1.18	2.72
Newman	Stanislaus	5	B00 6168	-120.962	38.182	214	1.24	4.10
Porterville	Tulare	5	C00 7077	-119.021	36.066	393	1.23	2.75
Sonora	Toulumne	5	B40 8353	-120.383	37.983	1724	2.49	5.42
Stockton	San Joaquin	5	B00 8560	-121.316	38.000	12	1.44	3.20
Tejon Rcho	Kern	5	C00 8839	-118.744	35.027	1425	1.30	2.60
Tiger Creek	Amador	5	B20 8928	-120.491	38.440	2355	3.42	8.03
Turlock	Stanislaus	5	B00 9073	-120.850	37.481	115	1.21	2.24
Yosemite	Mariposa	5	B50 9855	-119.583	37.750	3985	2.90	8.05
Big Bear Lake Da	San Bernardino	6	Y01 0741	-116.967	34.233	6815	5.22	15.06
Claremont PC	Los Angeles	6	Y01 1779	-117.709	34.097	1185	2.72	6.95
Colbys 53	Los Angeles	6	U05 1896	-118.111	34.301	3620	4.96	15.38
Cuyamaca	San Diego	6	Z07 2239	-116.583	32.983	4650	4.02	12.81
Elsinore	Riverside	6	Y02 2805	-116.950	33.930	1305	2.03	5.28
Escondido	San Diego	6	Z04 2862	-117.083	33.117	660	2.02	6.63

List of Stations for Study of Maximum Daily Rainfall

Station	County	Div	DA Sta #	Longitude	Latitude	Elev.	Average	Rec Max
Glendora West	Los Angeles	6	U05 3452	-117.859	34.140	822	3.16	8.20
Long Beach	Los Angeles	6	U05 5080	-118.199	33.768	180	2.10	5.50
Los Angeles	Los Angeles	6	U05 5115	-118.233	34.050	270	2.34	7.43
Newhall Soledad	Ventura	6	U03 6164	-118.533	34.533	1240	3.28	7.68
Oxnard 32	Ventura	6	U03 6569	-119.175	34.221	5	2.24	5.96
Port Hueneme	Ventura	6	U05 7080	-119.208	34.144	20	2.24	5.36
Redlands	Riverside	6	Y01 7306	-117.191	34.052	1318	1.72	3.44
Riverside	Riverside	6	Y01 7470	-117.378	34.003	990	1.51	4.42
San Bernardino	San Bernardino	6	Y01 7723	-117.267	34.163	1125	2.21	5.29
San Diego	San Diego	6	Z08 7740	-117.167	32.733	19	1.48	3.23
San Jacinto	Riverside	6	Y02 7813	-116.958	33.787	1560	1.68	3.35
Santa Barbara	Santa Barbara	6	T15 7902	-119.700	34.417	100	2.84	8.00
Santa Monica	Los Angeles	6	U05 7950	-118.491	34.012	64	2.43	5.82
Santa Paula	Ventura	6	U03 7958	-119.077	34.345	640	2.82	10.00
Sweetwater Dam	San Diego	6	Z09 8226	-117.008	32.693	250	1.51	5.20
Tustine Irvine	Orange	6	Y01 9075	-117.782	33.731	118	1.85	4.52
Independence	Inyo	7	W03 4232	-118.185	36.801	3950	1.14	5.72
Indio	Riverside	7	X19 4259	-116.224	33.713	8	1.05	6.45
Needles	San Bernardino	7	X13 6118	-114.617	34.767	910	1.07	3.49
Yuma	AZ	7	X27 9890	-114.617	32.733	240	3.27	10.80

	Average	Rec Max
Average	2.42	6.16
Maximum	5.22	15.38
Minimum	0.86	2.24
Count	98	98

Averages for Climatic Divisions of the National Climatic Data Center		Count	Avg	Max
North Coast	1	12	3.29	7.57
Sacramento Valley	2	24	2.80	6.55
Central Coast	4	20	2.07	5.51
San Soaquin Valley	5	16	1.66	3.94
South Coast	6	22	2.56	7.07
Desert	7	4	1.63	6.62
All Stations		98	1.80	6.91

Addendum: Water Year 1995

Water Year 1995 (Map 29 on page 99)

Water year 1995 (from October 1, 1994 to September 30, 1995) has the third highest rainfall total in over a hundred years. It was exceeded only by rainfall totals for the years 1890 and 1983. Historically, the years of large rainfall totals were not necessarily the years of heavy flood-producing rainfalls. Nineteen ninety-five, however, may be an exception as there were numerous periods of robust rainfall activity throughout the State. One hundred stations reported the highest ever water year total precipitation. Thirty stations reported over 100 inches for the year; among these were Magalia 2 N with 132.49 and Cobb with 129.58 inches.

The station with the highest return period for total rainfall in 1995 was Black Butte Ranch which had 46.06 inches in 1995 when its average is only 19.94 inches. The return period for Black Butte Ranch was 4,300 years. Florence Lake in the upper San Joaquin River Basin had 50.29 inches with a 1,300-year return period. Panoche 2 W, located near the crest of the Coast Range in the San Joaquin Valley, had 21.36 inches with a 1,900-year return period.

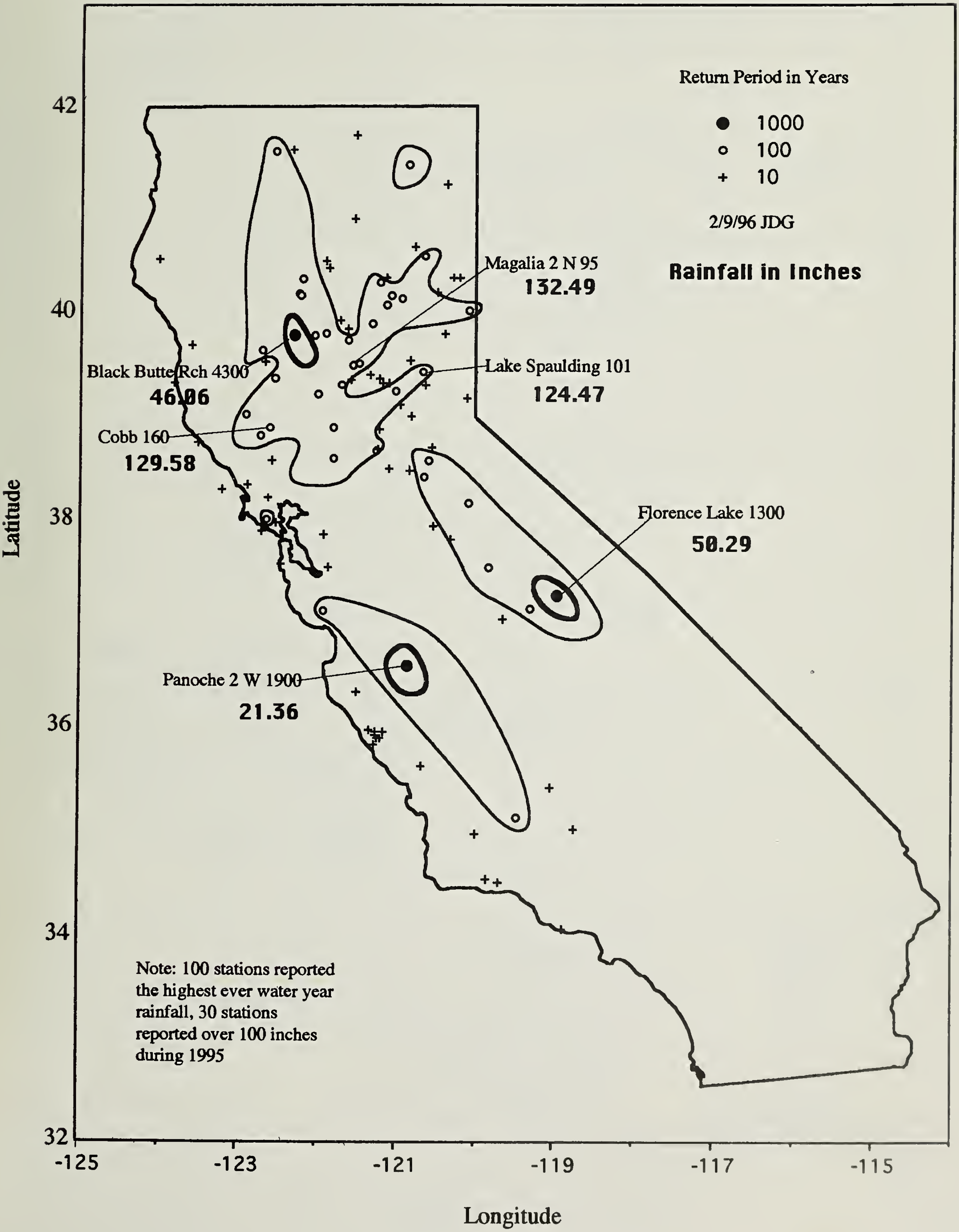
Most of the stations reporting over 100 inches for the year were located in the Feather and Yuba River Basins. Here is a brief summary of some of the more notable storms of California for water year 1995.

Storm of October 4, 1994

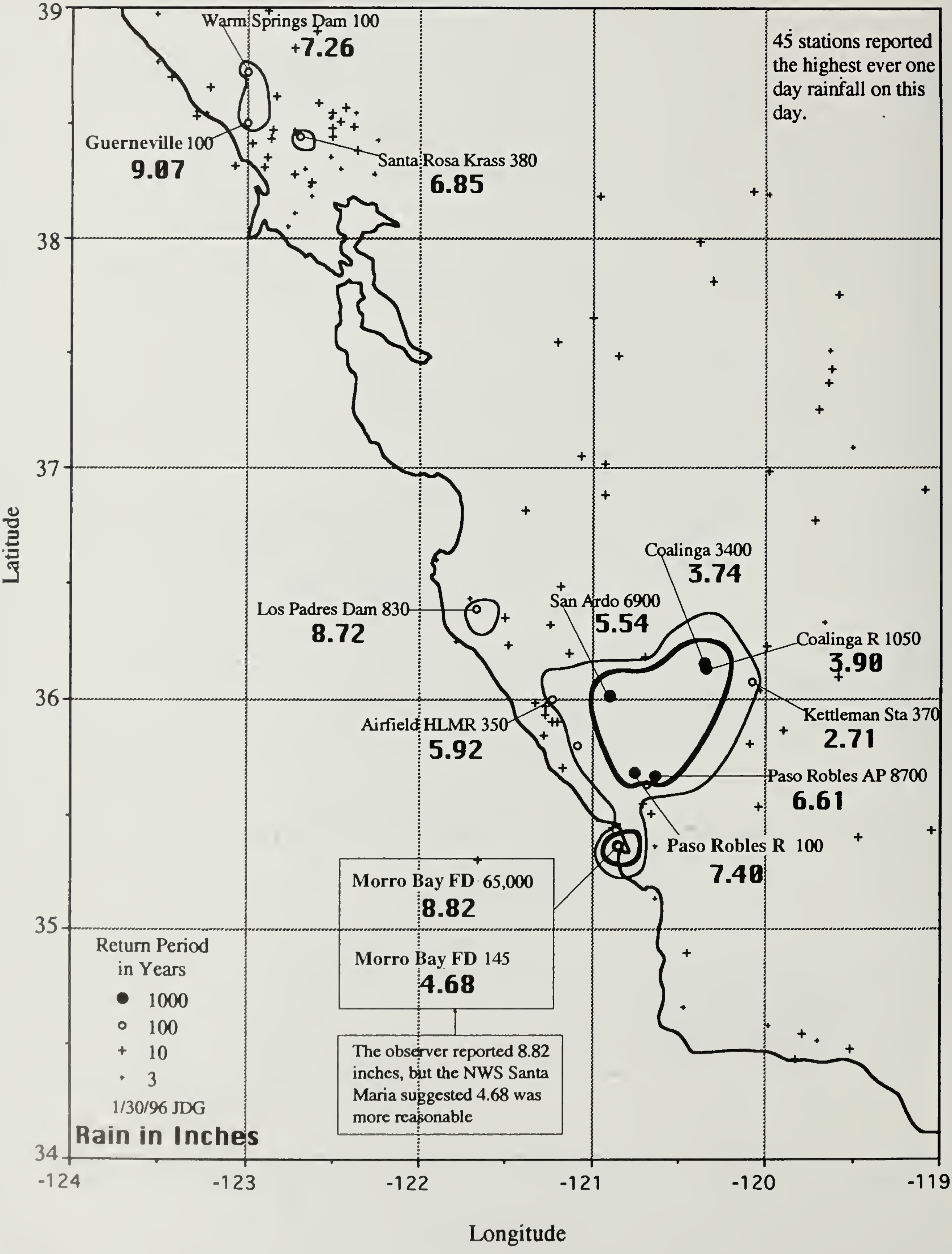
California is a region of relatively few thunderstorms, yet an unusual thunderstorm occurred in Sacramento County on October 4, 1994. The Cresta Park raingage recorded 1.02 inches of rain in 15 minutes. This exceeded the once-in-a-thousand-year rainfall for 15 minutes at the Cresta Park rainfall station. The previous high 15-minute rainfall at Cresta Park was 0.58 in 1961. This storm deposited a narrow band of heavy precipitation extending from Branch Center north eastward to the Navion gage in Citrus Heights.

Storm of November 5, 1994

Heavy rains fell on November 5, 1994 – over 8 inches in 1 day at Lake Lagunitas and Corte Madera in Marin County. These were not unusual amounts of rain for these relatively wet locations; but to the south, San Francisco received 5.54 inches on this day. This was the largest one-day



Return Period in Years
1000
100
10
2/9/96 JDG
Rainfall in Inches
Magalia 2 N 95
132.49
Black Butte Rch 4300
46.06
Lake Spaulding 101
124.47
Cobb 160
129.58
Florence Lake 1300
50.29
Panoche 2 W 1900
21.36
Note: 100 stations reported the highest ever water year rainfall, 30 stations reported over 100 inches during 1995
Latitude
42
40
38
36
34
32
-125
-123
-121
-119
-117
-115
Longitude


Warm Springs Dam 100
+7.26
45 stations reported the highest ever one day rainfall on this day.
Guerneville 100
9.07
Santa Rosa Krass 380
6.85
Coalinga 3400
3.74
Los Padres Dam 830
8.72
San Ardo 6900
5.54
Coalinga R 1050
3.90
Airfield HLMR 350
5.92
Kettleman Sta 370
2.71
Paso Robles AP 8700
6.61
Paso Robles R 100
7.40
Morro Bay FD 65,000
8.82
Morro Bay FD 145
4.68
The observer reported 8.82 inches, but the NWS Santa Maria suggested 4.68 was more reasonable
Return Period in Years
1000
100
10
3
1/30/96 JDG
Rain in Inches
Latitude
39
38
37
36
35
34
-124
-123
-122
-121
-120
-119
Longitude

rainfall in San Francisco based on midnight to midnight readings since the record began 146 years ago. However, in 1866, 7.76 inches fell between 11:45 a.m. on December 19 and 8:15 a.m. on December 20, 1866.

The heavy rainfalls of November 5, 1994, at San Francisco resulted from a normal winter-time storm front that stagnated over the San Francisco region with a northeast-southwest orientation and produced a narrow band of very heavy rainfall. Stephen Holets reported in *Weatherwise*, Volume 48, Number 3, June/July 1995, that the November 4, 1994, storm was remarkable because of the sharp rainfall gradient for a nonconnective storm; San Jose, located 50 miles from San Francisco, received less than a quarter of an inch.

Storm of January 3, 1995

Large rainfalls occurred in San Luis Obispo and Santa Barbara Counties during January. A new high rainfall was reported for Santa Barbara which had 8.00 inches on January 3, 1995. This was the largest one-day rain in its 125-year record. Santa Barbara was apparently near the center of a thunderstorm on that day.

Storm of January 7-13, 1995 **(Map 30 on page 100)**

Record-breaking rainfalls occurred during the six days from January 7 to January 12, 1995, on the west side of the Sacramento Valley. Fifty stations reported the greatest ever six-day total rainfall. Cobb in the Clear Lake Basin received 35.18 inches in six days. The largest return period, from the records collected, was for Greenville in the Feather River Basin where 30.50 inches in six days had a return period of 2,400 years.

The main precipitation band for this storm series was located in a band extending from Clear Lake northeast to the Lake Almanor region. Another band of high rainfalls extended from Whiskeytown north to the McCloud region in the Upper Sacramento River Basin.

Storm of January 10, 1995 **(Map 31 on page 102)**

Embedded in the January 7 to 12 storm was the January 10, 1995 event northeast of Sacramento. The peak 24-hour rainfall was 7.57 inches at the Granite Bay Country Club raingage. This peak 24-hour storm consisted of three separate rainfall sequences; the first from about 7 to 11 p.m. on

January 9, the second and heaviest from 4 to 8 a.m. on January 10, and another burst of rain from about 1 to 5 p.m., also on January 10.

Return periods represent the average time in years between storms of a given magnitude. They are calculated for stations with well-organized and readily-available rain records; hence, they are not available for all records. The largest return period from the January 10 storm was 4,000 years from 5.63 inches of rainfall at Rancho Cordova. This was from the raingage of Joe Ferrara, who kept a rain record there for 28 years. Thirty-eight stations reported the greatest ever one-day rainfall. Twelve Sacramento area stations reported over five inches of rain in one day.

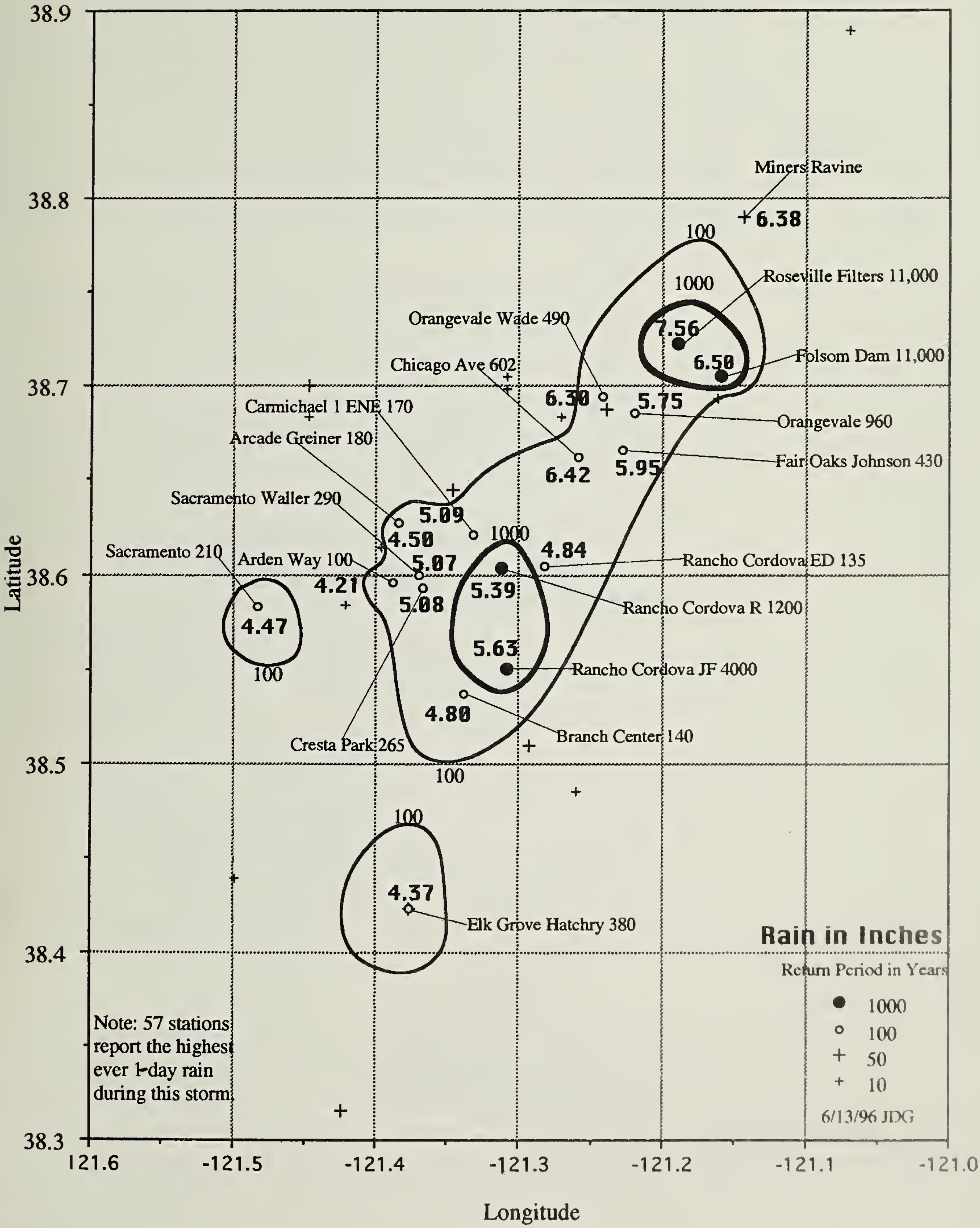
The January 10, 1995 storm in the Sacramento area was a low-elevation event somewhat similar to the Columbus Day storm of 1962, when 5.51 inches fell on October 13, 1962, at Citrus Heights. Unlike the 1962 Columbus Day storm, however, the January 10, 1995 rainstorm fell on saturated ground. It was preceded by eight days of rain. High antecedent rains preceding record rainfalls resulting in devastating flooding in the Sacramento area centered on Linda Creek which flows through Roseville and Rio Linda.

Storm of March 10, 1995 **(Map 32 on page 104)**

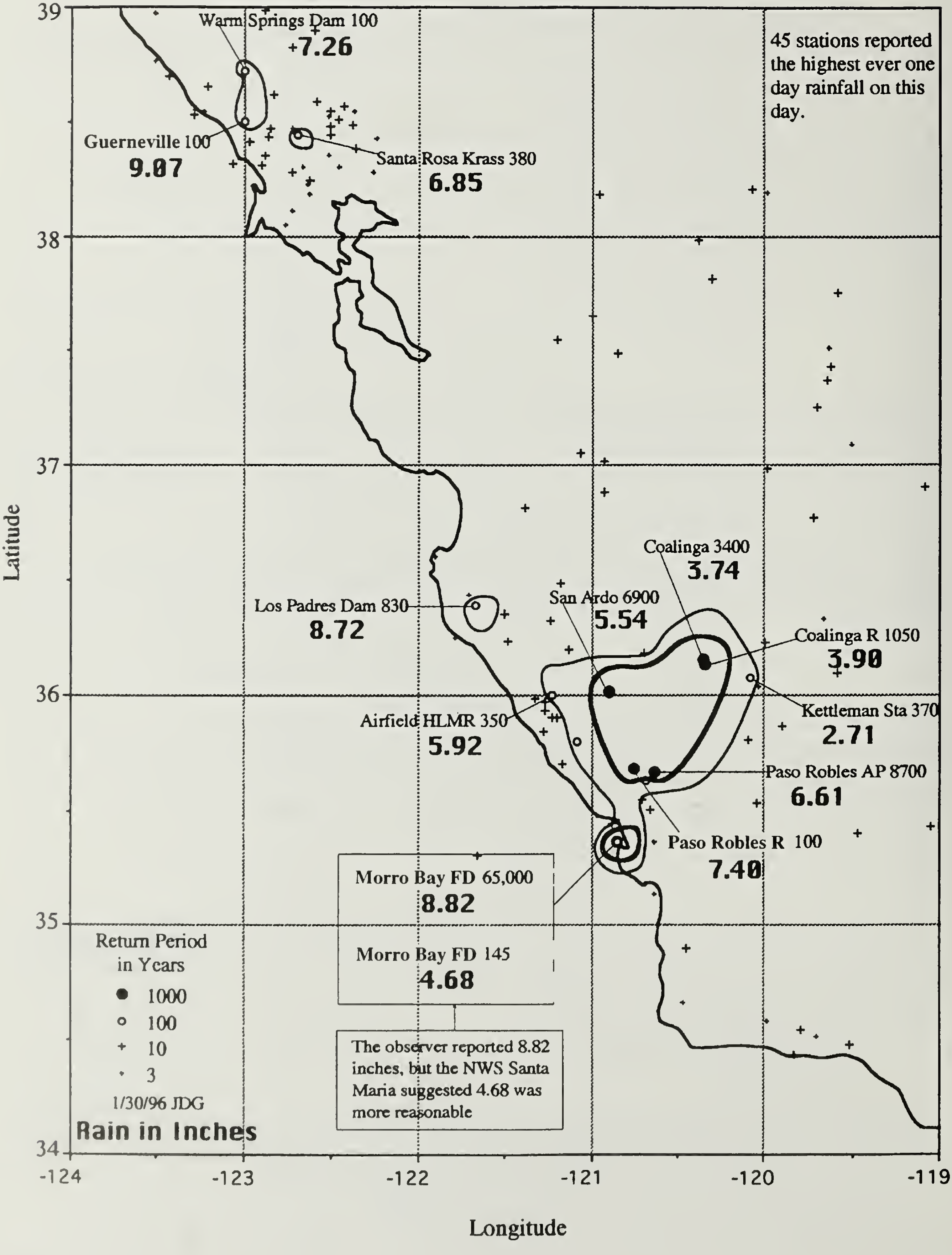
February was a dry month in almost all of California except perhaps in the mountains of the South Coastal Basin. The dry spell was broken by the new record rainfalls of March. The heaviest March rainfalls occurred mainly between March 9 and 10. There were two centers of heavy activity.

The Napa and Russian River Basins received heavy rainfalls on March 9. The heaviest rainfall was 9.07 inches at Guerneville. This event had a return period of 100 years. Severe flooding resulted on both the Napa and Russian Rivers. Flooding apparently occurs on these streams when only small parts of the watersheds have large rainfalls.

The highest ever flood stages were reported on the Salinas River at the Spreckles Highway Bridge. Upstream on the Salinas River, four stations reported the highest ever 24-hour rainfall. Paso Robles had a total of 7.40 inches. This event had a return period of about 1,100 years at Paso Robles.


Miners Ravine
6.38
100
1000
Roseville Filters 11,000
Orangevale Wade 490
7.56
Folsom Dam 11,000
6.50
Chicago Ave 602
6.30
5.75
Orangevale 960
Carmichael 1 ENE 170
Arcade Greiner 180
6.42
5.95
Fair Oaks Johnson 430
Sacramento Waller 290
5.09
4.50
1000
4.84
Sacramento 210
Arden Way 100
5.07
Rancho Cordova ED 135
4.21
5.39
Rancho Cordova R 1200
5.08
4.47
5.63
100
Rancho Cordova JF 4000
4.80
Branch Center 140
Cresta Park 265
100
100
4.37
Elk Grove Hatchry 380
Rain in Inches
Return Period in Years
1000
100
50
10
6/13/96 JDG
Note: 57 stations report the highest ever 1-day rain during this storm.
Latitude
38.9
38.8
38.7
38.6
38.5
38.4
38.3
121.6
-121.5
-121.4
-121.3
-121.2
-121.1
-121.0
Longitude

Map 32 Storm of March 10, 1995



The March 10 storm on the upper Salinas River spilled over the coast range into the San Joaquin Valley near Coalinga where flooding on Arroyo Pasajero Creek washed away an Interstate Highway 5 bridge over Arroyo Pasajero, the main north-south highway in the State. Coalinga had a record-breaking 3.74 inches of rain exceeding its previous record of 2.53 inches in 1914. The return period for the Coalinga rain of this storm was 2,400 years. The highest ever rainfalls also occurred at Kettleman Station and Westhaven. Fresno matched its previous maximum daily rain of 2.38 inches which occurred in 1905.

There is a remarkable similarity in rainfall distribution between the March 9, 1995 storm and the February 10, 1978 cyclonic storm which dumped record rainfalls in an area to the south of the area affected by this storm. It produced large rainfalls on the windward slopes of Ventura County and then continued over into the rain shadow area in the Buena Lake region. The March 9, 1995 storm behaved in a similar manner. It appeared to be a cyclonic storm since it produced devastating rainfalls on the windward slopes of the coast range. It was still quite energetic as it moved into the rain shadow area to create further devastating floods. A similar cyclonic storm came ashore near Monterey in September 1918 resulting in extreme rainfalls at Antioch, again in the rain shadow zone. The 1918 storm was a tropical cyclone which originated off the southwest coast of Mexico.

It is generally assumed that the weather observer is always right. Controversy regarding observer's rainfall measurements is rare. One of these rare events occurred between the National Weather Service Office at Santa Maria and the weather observer at the Morro Bay Fire Department regarding the rainfall reported for March 11, 1995. It was reported in the *San Luis Obispo Telegraph-Tribune* of March 21, 1995.

The Fire Department reported 8.82 inches on March 11 and the Weather Service suggested that 3.50 was the correct value, based on nearby reports. If the Fire Department value is correct, the return period for the two-day event is over 300,000 years. If the Weather Service is right, the return period is about 800 years, a value consistent with surrounding stations.

Since an observer is seldom found to be wrong, and since a real storm

with a very rare return period is extremely important in drainage engineering studies as well as in forensic meteorology (there were several deaths), this event merits continued study.

Storm of May 5, 1995

Another of the unusual thunderstorms occurred in Sacramento County on May 5, 1995. The Van Marin Lane raingage in Citrus Heights had 1.14 inches of rain in 30 minutes. This exceeded the once-in-a-hundred-year rainfall for the Van Marin raingage.

Tables

Table 1 Major 1,000-Year Rainfalls for California

12/1/95 7:23 Station	Station Number	Max Rain	Mean	Max SD	Return Period 1000 yrs	Previous Max Inches	Previous Max Year	Yrs Rec	Lat dd.ddd	Long ddd.ddd	Elev feet	Date	JDG Days
Colusa	A00 1948 00	**5.60**	1.58	7.23	42.0	3.12	1911	90	39.200	-122.017	60	1916/01/03	1
Ferguson Ranch	A00 3020 00	**12.00**	2.95	8.72	380.0	6.30	1980	25	40.350	-122.450	800	1980/12/03	1
Rancho Cordova JF	A00 7247 0?	**5.63**	1.86	5.76	4.0	3.11	1991	28	38.643	-121.308	85	1995/01/10	1
Sacramento	A00 7633 00	**8.37**	2.58	5.80	3.5	5.80	1963	123	38.583	-121.483	25	1880/04/20-21	2
Willows	A00 9699 00	**40.39**	17.18	4.36	5.8	36.95	1983	110	39.533	-122.200	140	1941 Water Yea	365
Alturas RS	A10 2964 00	**5.08**	1.34	7.21	24.0	3.35	1963	73	41.483	-120.533	4365	1937/12/10-11	2
Harrison Gulch	A30 3791 00	**12.60**	3.30	8.01	130.0	82.00	1982	45	40.367	-122.967	2710	1970/12/03	1
La Porte	A50 4773 00	**57.41**	18.63	5.38	12.2	42.62	1907	34	39.682	-120.983	4975	1909/01/1-20	20
Kelseyville 2N	A80 4491 01	**70.12**	25.35	5.70	160.0	40.61	1941	36	38.976	-122.831	1385	1983 Water Yea	365
Belotta	B00 0637 01	**6.37**	1.88	0.06	21.0	3.78	1925	20	38.044	-121.058	108	1916/01/14	1
Fancher Ranch	B00 2968 00	**4.00**	1.29	5.93	6.3	2.40	1926	64	37.318	-120.334	225	1925/04/25	1
Newman	B00 6168 00	**24.98**	10.48	4.48	7.8	19.34	1983	109	37.350	-121.083	108	1890 Water Yea	365
Oakdale Woodward	B00 6305 00	**5.72**	1.42	8.55	300.0	1.70	1963	19	37.867	-120.867	220	1958/04/03	1
Newman	B00 9418 00	**4.10**	1.22	6.67	18.5	2.30	1971	90	37.350	-121.083	108	1988/01/17	1
Florence Lake	B70 3093 00	**14.50**	3.76	7.04	33.0	12.20	1956	66	37.273	-118.974	7350	1963/01/30-02/0	3
Antioch	B80 0232 00	**6.59**	2.12	5.19	2.2	5.66	1911	93	37.984	-121.728	60	1918/09/12-14	3
Buttonwillow	C00 1244 00	**3.41**	0.82	7.41	28.0	1.56	1988	53	35.400	-119.467	268	1978/02/10	1
Tulare	C00 9051 00	**3.89**	1.14	5.66	2.7	1.94	1978	21	36.213	-119.331	293	1898/09/26	1
Kern Intake 3 SCE	C50 4519 00	**23.57**	4.45	8.93	130.0	9.67	1963	51	35.945	-118.476	3642	1966/12/3-7	5
Forest Lake	D40 3135 10	**6.07**	1.67	6.38	9.7	3.32	1901	86	36.592	-121.942	295	1906/12/11	1
Point Reyes Light	E10 7027 00	**5.96**	1.73	6.05	4.8	2.90	1900	37	38.183	-122.850	490	1982/01/04	1
Atlas Road	E30 0372 00	**41.08**	10.38	7.43	94.0	21.59	1956	24	38.427	-122.248	1660	1986/02/11-20	10
Upr San Leandro Filte	E40 9185 00	**13.14**	3.47	6.54	6.8	6.31	1982	48	37.800	-122.140	490	1962/10/3Days	3
Calaveras Dam	E50 1281 00	**7.17**	1.82	7.28	23.0	3.90	1965	78	37.487	-121.818	805	1950/11/18	1
Lake McKenzie	E60 4688 00	**42.27**	12.22	6.09	6.6	21.54	1932	33	37.217	-122.067	1809	1955/12/16-28	8
San Andreas Lake	E70 7704 00	**27.16**	5.29	9.70	360.0	8.43	1979	122	37.583	-122.400	377	1871/12/18-20	3
San Francisco	E80 7772 00	**28.25**	8.07	6.48	37.0	18.19	1872	144	37.783	-122.417	52	1861/23-1/21	30
San Francisco R	E80 7772 00	**7.76**	2.20	6.26	6.2	5.90	1982	105	37.783	-122.417	52	1866/12/21	1
Gazelle	F20 3363 05	**8.09**	2.16	7.78	360.0	3.52	1982	18	41.575	-122.543	2690	1964/12/6Days	6
Orick PC	F50 6498 00	**11.50**	3.90	5.52	4.8	5.56	1939	55	41.637	-124.017	161	1950/10/29	1
Morro Bay FD	T10 5866 00	**8.82**	1.98	8.05	65.0	3.08	1963	36	35.367	-120.850	115	1995/03/10	1
Dry Canyon Res	U03 2516 00	**17.14**	4.30	5.49	3.1	9.34	1926	61	34.482	-118.523	1511	1983/02/25-2	6
Anza Foothill Rch 99	U05 0410 01	**16.33**	4.39	5.23	1.4	11.65	1916	61	34.132	-117.892	615	1934/0101	2
Edison Intake 75	U05 2681 30	**15.46**	4.50	4.99	1.0	8.15	1927	32	34.211	-117.858	1275	1921/12/20	1
Hoegees	U05 4017 00	**36.34**	8.45	6.35	5.4	18.01	1926	55	34.208	-118.020	2412	1943/01/22-23	2
Independence	W03 4232 00	**14.55**	3.00	6.50	8.4	11.63	1967	92	36.801	-118.185	3950	1969 Jan-Feb	60
Indio	X19 4529 00	**6.45**	1.05	8.19	27.0	3.16	1978	88	33.713	-116.224	8	1939/09/24	1
Mission Creek	X19 5718 61	**19.17**	4.89	6.13	9.1	9.90	1969	19	34.011	-116.627	2400	1993/01/05-19	15
Brawley 2 SW	X23 1048 00	**6.33**	1.06	7.78	17.0	4.84	1977	60	32.954	-115.558	-100	1939/09/ 5&6	2
Yuma Valley AZ	X27 9890 80	**6.45**	0.88	10.84	600.0	1.73	1989	56	32.717	-114.717	120	1977/08/16	1
Big Bear Lake Dam	Y01 0742 00	**32.20**	7.34	7.02	17.0	21.75	1916	101	34.230	-116.970	6897	1891/12/22	2
Encinitas	Z04 2833 00	**7.58**	1.84	6.55	73.0	1.70	1974	13	32.050	-117.283	300	1889/10/12	1
Descauso RS	Z09 2406 00	**27.79**	7.23	5.97	6.7	16.19	1980	31	32.856	-116.623	3500	1916/01/14-28	15
Campo	Z11 1424 00	**16.10**	2.20	13.39	10000	7.10	1922	92	32.628	-116.469	2612	1891/08/12	1
Morena Dam	Z11 5840 00	**16.65**	4.02	6.73	6.6	8.49	1940	64	32.686	-116.522	3075	1927/02/13-17	4
Average		16.89	4.74	6.73	290.3	11.61	1952	61	36.815	-120.097	1433		29
Maximum		70.12	25.35	13.39	10,000	82.00	1991	144	41.637	-114.717	7350		365
Minimum		3.41	0.82	0.06	1.0	1.56	1872	13	32.050	-124.017	-100		1
Count		45	45	45	45	45	45	45	45	45	45		45

1,000-Year Rainfalls for California (1 of 5) Table 2

12/1/95 8:12 Station	Station Number	Max Rain	Mean	Max SD	Return Period 1000 yrs	Previous Max Inches	Year	Yrs Rec	Lat dd.ddd	Long ddd.ddd	Elev feet	Date	JDG Days
Sacramento	A00 7633 00	**19.36**	7.14	4.52	2.3	15.24	1880	123	38.583	-121.483	25	1861/23-1/21	30
San Francisco	E80 7772 00	**28.25**	8.07	6.48	37.0	18.19	1872	144	37.783	-122.417	52	1861/23-1/21	30
San Francisco R	E80 7772 00	**7.76**	2.20	6.26	6.2	5.90	1982	105	37.783	-122.417	52	1866/12/21	1
San Andreas Lake	E70 7704 00	**27.16**	5.29	9.70	360.0	8.43	1979	122	37.583	-122.400	377	1871/12/18-20	3
Pilarcitos	E80 6863 00	**20.92**	6.04	5.78	2.5	16.13	1963	126	37.547	-122.421	625	1871/12/18-20	3
Sacramento	A00 7633 00	**8.37**	2.58	5.80	3.5	5.80	1963	123	38.583	-121.483	25	1880/04/20-21	2
Encinitas	Z04 2833 00	**7.58**	1.84	6.55	73.0	1.70	1974	13	32.050	-117.283	300	1889/10/12	1
Davis	A00 2294 00	**38.03**	17.26	3.88	1.7	35.71	1983	109	38.533	-121.767	60	1890 Water Yea	365
Gridley Butte WD	A00 3640 00	**47.79**	22.24	3.71	1.1	43.46	1983	109	39.367	-121.695	90	1890 Water Yea	365
Dunsmuir	A20 2572 00	**120.27**	55.06	3.82	1.4	111.14	1983	109	41.217	-122.267	2420	1890 Water Yea	365
Newman	B00 6168 00	**24.98**	10.48	4.48	7.8	19.34	1983	109	37.350	-121.083	108	1890 Water Yea	365
Sonora	B40 9353 00	**69.08**	32.10	3.73	1.1	59.78	1983	104	37.983	-120.383	1745	1890 Water Yea	365
Mariposa	B50 5354 00	**66.78**	30.87	3.76	1.2	58.05	1983	103	37.490	-119.970	2011	1890 Water Yea	365
Los Gatos	E70 5123 00	**67.41**	28.06	4.17	2.3	56.47	1893	109	37.217	-121.983	428	1890 Water Yea	365
Upper Crystal Sp	E70 9163 00	**72.71**	29.38	4.39	3.8	59.96	1879	116	37.500	-122.350	300	1890 Water Yea	365
Campo	Z11 1424 00	**16.10**	2.20	13.39	10000	7.10	1922	92	32.628	-116.469	2612	1891/08/12	1
Big Bear Lake Dam	Y01 0742 00	**32.20**	7.34	7.02	17.0	21.75	1916	101	34.230	-116.970	6897	1891/12/22	2
Tulare	C00 9051 00	**3.89**	1.14	5.66	2.7	1.94	1978	21	36.213	-119.331	293	1898/09/26	1
Forest Lake	D40 3135 10	**6.07**	1.67	6.38	9.7	3.32	1901	86	36.592	-121.942	295	1906/12/11	1
La Porte	A50 4773 00	**57.41**	18.63	5.38	12.2	42.62	1907	34	39.682	-120.983	4975	1909/01/1-20	20
Camptonville	A60 1462 00	**48.60**	18.32	4.27	1.4	40.99	1965	62	39.451	-121.048	2755	1909/01/1-20	20
Bellota	B00 0637 01	**6.37**	1.88	0.06	21000	3.78	1925	20	38.044	-121.058	108	1916/01/14	1
Escondido	Z04 2862 00	**17.84**	5.41	4.83	1.3	12.66	1927	94	33.117	-117.008	660	1916/01/14-28	15
El Cajon	Z07 2702 00	**15.74**	4.42	5.38	2.8	11.64	1927	43	32.795	-116.971	460	1916/01/14-28	15
Descauso RS	Z09 2406 00	**27.79**	7.23	5.97	6.7	16.19	1980	31	32.856	-116.623	3500	1916/01/14-28	15
Barrett Dam	Z11 0514 00	**20.71**	5.74	5.48	3.3	17.47	1927	75	32.683	-116.667	1623	1916/01/14-28	15
Campo	Z11 1424 00	**19.66**	5.45	5.48	3.3	16.50	1927	90	32.628	-116.469	2630	1916/01/14-28	15
Henshaw Dam	Z03 3914 00	**29.69**	9.21	4.67	1.0	27.05	1927	80	33.233	-116.767	2700	1916/01/14-28	15
Chico	A00 1715 00	**5.73**	2.16	4.70	1.1	4.26	1912	88	39.700	-121.817	185	1916/01/03	1
Colusa	A00 1948 00	**5.60**	1.58	7.23	42.0	3.12	1911	90	39.200	-122.017	60	1916/01/03	1
Antioch	B80 0232 00	**6.59**	2.12	5.19	2.2	5.66	1911	93	37.984	-121.728	60	1918/09/12-14	3
San Ardo	D20 7716 00	**20.65**	7.39	4.26	1.4	16.86	1958	75	36.003	-120.900	440	1969 Jan-Feb	60
Juncal Dam	T14 4422 00	**72.64**	19.37	5.47	2.2	44.22	1978	46	34.483	-119.517	2060	1969 Jan-Feb	60
Piedra Blanca GS 152	U03 6862 01	**54.44**	16.01	4.64	1.2	41.24	1978	35	34.561	-119.116	3065	1969 Jan-Feb	60
Wheeler Springs 63	U03 9610 00	**50.51**	14.81	4.66	1.2	37.68	1978	38	34.439	-119.189	1320	1969 Jan-Feb	60
Wheeler Springs 7N	U03 9618 00	**50.51**	15.03	4.57	1.1	38.57	1978	48	34.597	-119.325	4150	1969 Jan-Feb	60
Big Santa Anita Dam	U05 0785 01	**55.30**	15.58	4.93	1.9	42.92	1980	60	34.185	-118.019	1400	1969 Jan-Feb	60
Clear Creek School 47	U05 1788 11	**69.71**	19.63	4.93	1.9	44.01	1943	61	34.278	-118.171	3200	1969 Jan-Feb	60
Falling Springs 51	U05 2961 11	**66.66**	19.21	4.78	1.6	48.18	1938	44	34.302	-117.872	4010	1969 Jan-Feb	60
San Gabriel Dam Cam	U05 7779 01	**60.87**	17.72	4.71	1.4	40.39	1938	42	34.226	-117.857	1500	1969 Jan-Feb	60
Big Pine PH 3	W03 0776 00	**24.33**	6.03	5.13	1.2	15.47	1967	50	37.126	-118.323	5400	1969 Jan-Feb	60
Bishop AP	W03 0822 00	**15.03**	3.26	6.10	5.2	9.23	1952	57	37.367	-118.367	4108	1969 Jan-Feb	60
Independence	W03 4232 00	**14.55**	3.00	6.50	8.4	11.63	1967	92	36.801	-118.185	3950	1969 Jan-Feb	60
Cajon Junction 16a	W28 1267 01	**48.33**	11.94	5.15	1.2	39.54	1978	47	34.312	-117.475	3118	1969 Jan-Feb	60
Big Big Lake	Y01 0741 00	**46.85**	13.51	4.92	2.3	33.34	1980	33	34.250	-116.917	6750	1969 Jan-Feb	60
Big Bear Lake Dam	Y01 0742 00	**73.65**	22.86	4.43	1.1	66.98	1884	91	34.233	-116.967	6815	1969 Jan-Feb	60

Table 2 1,000-Year Rainfalls for California (2 of 5)

12/1/95 8:12 Station	Station Number	Max Rain	Mean	Max SD	Return Period 1000 yrs	Previous Max Inches	Previous Max Year	Yrs Rec	Lat dd.ddd	Long ddd.ddd	Elev feet	Date	JDG Days
Glen Ivy	Y01 3458 11	**37.85**	10.89	4.93	2.7	25.27	1938	84	33.766	-117.487	1100	1969 Jan-Feb	60
Lytle Creek PH	Y01 5215 01	**74.33**	21.93	4.76	1.9	46.45	1916	71	34.202	-117.450	2225	1969 Jan-Feb	60
Mt Baldy 85	Y01 5900 00	**79.33**	20.34	5.78	2.6	50.22	1943	57	34.237	-117.659	4275	1969 Jan-Feb	60
Mt Baldy Notch	Y01 5901 00	**88.50**	21.95	6.04	2.7	46.65	1966	16	34.274	-117.614	7735	1969 Jan-Feb	60
Upper Drive	Y01 9163 25	**34.90**	10.94	4.36	1.0	27.43	1980	58	33.834	-117.579	1250	1969 Jan-Feb	60
Edison Intake 75	U05 2681 30	**15.46**	4.50	4.99	1.0	8.15	1927	32	34.211	-117.858	1275	1921/12/20	1
Fancher Ranch	B00 2968 00	**4.00**	1.29	5.93	6.3	2.40	1926	64	37.318	-120.334	225	1925/04/25	1
Palm Springs East	X19 6635 5(	**10.30**	2.01	6.40	3.5	6.50	1943	79	33.827	-116.510	425	1927/02/13-17	4
Murrieta	Z02 6042 00	**15.75**	4.39	5.54	1.4	13.11	1943	50	33.555	-117.332	1100	1927/02/13-17	4
Henshaw Dam	Z03 3914 00	**25.38**	6.22	6.60	5.6	16.61	1916	80	33.233	-116.767	2700	1927/02/13-17	4
Barrett Dam	Z11 0514 00	**14.84**	3.76	6.31	4.0	10.69	1916	75	32.683	-116.667	1623	1927/02/13-17	4
Campo	Z11 1424 00	**13.55**	3.59	5.94	2.4	10.50	1916	90	32.628	-116.471	2612	1927/02/13-17	4
Morena Dam	Z11 5840 00	**16.65**	4.02	6.73	6.6	8.49	1940	64	32.686	-116.522	3075	1927/02/13-17	4
Potrero	Z11 7100 00	**14.65**	4.14	5.44	1.3	7.97	1966	47	32.631	-116.620	2390	1927/02/13-17	4
Malibu Lakeside 4	U04 5269 45	**19.49**	5.39	5.03	1.1	16.39	1969	34	34.103	-118.754	800	1934/01/01	2
Anza Foothill Rch 99	U05 0410 01	**16.33**	4.39	5.23	1.4	11.65	1916	61	34.132	-117.892	615	1934/01/01	2
Alturas RS	A10 2964 00	**5.08**	1.34	7.21	24.0	3.35	1963	73	41.483	-120.533	4365	1937/12/10-11	2
Inskip Inn	A50 4274 00	**18.37**	5.41	6.19	5.8	13.23	1914	29	40.000	-121.533	4818	1937/12/10-11	2
Indio	X19 4529 00	**6.45**	1.05	8.19	27.0	3.16	1978	88	33.713	-116.224	8	1939/09/24	1
Imperial	X23 4223 00	**4.08**	0.90	5.63	1.3	2.35	1977	54	32.850	-115.567	-64	1939/09/24	1
Iron Mtn Pump	X12 4297 00	**5.39**	1.05	6.47	3.7	2.29	1949	53	34.133	-115.133	900	1939/09/ 5&6	2
Hayfield Pump	X18 3855 00	**5.55**	1.22	5.55	1.3	3.19	1983	52	33.700	-115.633	1370	1939/09/ 5&6	2
Brawley 2 SW	X23 1048 00	**6.33**	1.06	7.78	17.0	4.84	1977	60	32.954	-115.558	-100	1939/09/ 5&6	2
Plainfield	A00 5805 00	**36.71**	16.77	3.84	1.5	25.92	1909	69	38.588	-121.795	63	1941 Water Yea	365
Orland	A00 6506 00	**41.12**	18.89	3.80	1.3	40.63	1983	109	39.750	-122.200	254	1941 Water Yea	365
Williams	A00 9677 00	**32.55**	14.39	4.07	2.7	31.94	1983	110	39.150	-122.150	90	1941 Water Yea	365
Willows	A00 9699 00	**40.39**	17.18	4.36	5.8	36.95	1983	110	39.533	-122.200	140	1941 Water Yea	365
Lompoc JM	T14 5064 40	**50.35**	18.35	4.05	1.7	33.64	1958	41	34.600	-120.450	570	1941 Water Yea	365
Rancho San Julian	T14 7249 26	**66.83**	23.46	4.29	3.1	50.27	1978	71	34.533	-120.333	600	1941 Water Yea	365
Santa Ynez	T14 7676 00	**43.25**	14.60	4.55	5.5	34.49	1983	50	34.617	-120.100	600	1941 Water Yea	365
Santa Paula	U03 7958 50	**14.19**	3.84	5.18	1.1	9.37	1962	90	34.340	-119.080	260	1943/01/22-23	2
Big Santa Anita Dam (	U05 0785 01	**19.33**	5.14	5.31	1.4	16.40	1969	60	34.185	-118.019	1400	1943/01/22-23	2
Big Tujunga Dam 46	U05 0798 00	**24.14**	6.36	5.38	1.5	16.79	1969	61	34.291	-118.197	2315	1943/01/22-23	2
Cedar Springs	U05 1613 01	**27.53**	6.68	6.00	2.9	15.70	1969	42	34.356	-117.876	6780	1943/01/22-23	2
Colbys	U05 1896 00	**26.74**	6.95	5.48	1.7	17.18	1969	87	34.301	-118.111	3620	1943/01/22-23	2
Hoegees	U05 4017 00	**36.34**	8.45	6.35	5.4	18.01	1926	55	34.208	-118.020	2412	1943/01/22-23	2
Girard Res 20	U05 4330 11	**16.40**	4.27	5.46	1.7	7.95	1980	56	34.152	-118.610	986	1943/01/22-23	2
San Gabriel Dam Can	U05 7779 01	**23.89**	6.36	5.30	1.3	16.97	1969	42	34.226	-117.857	1500	1943/01/22-23	2
Sawpit Hogback 69	U05 8022 11	**23.61**	5.82	5.88	2.5	12.98	1934	36	34.181	-117.972	1775	1943/01/22-23	2
Mt Baldy 85	Y01 5900 00	**27.18**	7.75	5.10	1.2	18.37	1922	57	34.240	-117.660	4275	1943/01/22-23	2
Orick PC	F50 6498 00	**11.50**	3.90	5.52	4.8	5.56	1939	55	41.637	-124.017	161	1950/10/29	1
La Paloma Rch	B50 4760 00	**4.62**	1.68	4.94	1.6	3.62	1958	20	37.467	-120.283	449	1950/11/18	1
Catheys Valley	B60 1588 00	**6.14**	2.05	5.64	4.1	4.76	1956	26	37.400	-120.050	1430	1950/11/18	1
Hornitos	B60 4105 00	**4.42**	1.65	4.74	1.1	3.06	1956	64	37.503	-120.247	850	1950/11/18	1
Yosemite R	B60 9855 00	**8.05**	2.90	5.02	1.7	6.92	1956	87	37.750	-119.583	3985	1950/11/18	1
Huntington Lake	B70 4176 00	**8.23**	3.00	4.92	1.4	7.28	1956	74	37.229	-119.229	7020	1950/11/18	1

12/1/95 8:12 Station	Station Number	Max Rain	Mean	Max SD	Return Period 1000 yrs	Previous Max Inches	Previous Max Year	Yrs Rec	Lat dd.ddd	Long ddd.ddd	Elev feet	Date	JDG Days
No Fork RS	B70 6252 00	**8.67**	3.05	5.21	2.3	5.74	1956	58	37.233	-119.504	2630	1950/11/18	1
Pacheco Pass	B80 6583 00	**5.79**	1.77	6.42	14.0	2.26	1971	13	37.067	-121.183	1320	1950/11/18	1
Panoche Pass R	B80 6583 00	**5.88**	2.09	5.12	1.9	3.08	1969	24	37.067	-121.204	850	1950/11/18	1
Calaveras Dam	E50 1281 00	**7.17**	1.82	7.28	23.0	3.90	1965	78	37.487	-121.818	805	1950/11/18	1
Winters Lewis	A00 9742 16	**14.13**	5.06	4.63	1.6	12.23	1932	58	38.558	-121.891	99	1955/12/16-28	8
Sierraville RS	A50 8218 00	**18.76**	6.30	5.11	3.0	18.11	1986	76	39.583	-120.369	4975	1955/12/16-28	8
Vinton	A50 9351 00	9.41	3.21	4.99	3.5	10.09	1986	49	39.819	-120.188	4945	1955/12/16-28	8
Soda Springs 1E	A60 8332 00	26.59	9.83	4.41	1.0	26.60	1964	91	39.326	-120.367	6885	1955/12/16-28	8
Calaveras R S	B30 1280 00	**25.41**	9.48	4.33	1.2	19.92	1969	36	38.200	-120.367	3343	1955/12/16-28	8
Yosemite	B50 9855 00	**21.84**	7.92	4.53	1.7	21.28	1986	80	37.750	-119.583	3985	1955/12/16-28	8
Big Creek P H 1	B70 0755 00	**18.67**	6.84	4.46	1.5	13.89	1962	34	37.200	-119.250	4930	1955/12/16-28	8
Florence Lake	B70 3093 00	**15.14**	5.02	5.20	5.9	14.76	1963	17	37.273	-118.974	7345	1955/12/16-28	8
Huntington Lake	B70 4176 00	20.27	7.60	4.30	1.1	20.66	1969	68	37.229	-119.229	7020	1955/12/16-28	8
Lockewood 2 N	D30 0212 00	**25.28**	8.86	4.42	1.1	16.43	1942	37	35.967	-121.083	303	1955/12/16-28	8
Big Basin Way	E60 0740 00	**28.87**	9.58	4.98	1.3	19.76	1986	48	37.250	-121.050	577	1955/12/16-28	8
Lake Elsman	E60 4682 00	**30.53**	9.90	5.16	1.6	25.21	1986	41	37.133	-121.933	1000	1955/12/16-28	8
Lake Kittredge SJW	E60 4686 00	**35.05**	10.80	5.56	3.1	25.29	1986	77	37.183	-122.017	1400	1955/12/16-28	8
Lake McKenzie	E60 4688 00	**42.27**	12.22	6.09	6.6	21.54	1932	33	37.217	-122.067	1809	1955/12/16-28	8
Los Gatos	E60 5123 00	**20.17**	6.63	5.06	1.4	11.73	1980	15	37.217	-121.983	428	1955/12/16-28	8
Los Gatos Res	E60 5123 01	**23.95**	7.13	5.84	4.6	19.99	1986	78	37.217	-121.950	205	1955/12/16-28	8
Montevina Filters	E60 5803 00	**28.93**	8.41	6.04	6.2	19.03	1986	78	37.200	-121.983	696	1955/12/16-28	8
Mountain View	E60 5897 01	**11.67**	3.76	5.21	1.7	7.77	1911	89	37.383	-121.830	75	1955/12/16-28	8
Saratoga Gap	E60 7998 02	**38.28**	12.82	4.92	1.2	21.05	1969	42	37.252	-122.122	2600	1955/12/16-28	8
Woodacre FS	F90 9770 00	**29.25**	11.18	4.71	2.4	14.80	1982	12	38.617	-122.650	350	1955/12/16-28	8
Oakdale Woodward	B00 6305 00	**5.72**	1.42	8.55	300.0	1.70	1963	19	37.867	-120.867	220	1958/04/03	1
Karnack	A00 4449 00	**8.14**	2.68	5.13	1.3	4.03	1986	34	38.787	-123.655	23	1962/10/3Days	3
Marysville	A00 5385 00	**9.26**	3.02	5.20	1.4	8.69	1984	96	39.660	-121.580	62	1962/10/3Days	3
Nicolaus	A00 6193 00	**8.63**	2.70	5.53	2.3	4.98	1914	80	38.900	-121.580	47	1962/10/3Days	3
Oroville Bridge	A00 6525 00	**11.93**	3.86	5.27	1.5	6.30	1926	80	39.510	-121.570	165	1962/10/3Days	3
Robbins	A00 7517 00	**8.03**	2.69	5.00	1.1	4.07	1956	41	38.867	-121.717	20	1962/10/3Days	3
Verona	A00 9307 00	**7.88**	2.57	5.20	1.4	3.53	1964	31	38.791	-121.596	43	1962/10/3Days	3
Wheatland 2 NE	A00 9605 00	**9.22**	2.89	5.52	2.3	4.50	1951	36	39.030	-121.390	105	1962/10/3Days	3
Wheatland Calpak	A00 9606 00	**10.50**	3.54	4.95	1.0	6.07	1956	26	38.990	-121.440	150	1962/10/3Days	3
Yuba City	A00 9871 00	**9.06**	2.87	5.43	1.8	4.36	1984	32	39.130	-121.605	60	1962/10/3Days	3
Adin R S	A10 0029 00	**6.47**	1.92	5.97	4.4	4.13	1967	40	41.380	-120.920	4193	1962/10/3Days	3
Canby RS	A10 1476 00	**6.24**	1.90	5.75	3.3	3.10	1982	30	41.450	-120.867	4310	1962/10/3Days	3
Mineral	A40 5679 00	**21.81**	7.21	5.10	1.2	14.70	1938	66	40.350	-121.600	4910	1962/10/3Days	3
Sierraville R S	A50 8218 00	**14.40**	4.46	5.61	2.6	10.75	1956	76	39.580	-120.370	4975	1962/10/3Days	3
Bangor	A60 0480 00	**14.61**	4.58	5.52	2.3	6.05	1975	32	39.390	-121.408	750	1962/10/3Days	3
HL Englebright Dam	A60 3800 00	**14.58**	4.67	5.35	1.7	6.82	1986	40	39.240	-121.266	580	1962/10/3Days	3
Hidden Valley	A60 3946 00	**14.00**	4.71	4.97	1.0	7.47	1965	30	39.030	-121.090	1978	1962/10/3Days	3
Chabot Res	E40 1648 00	**11.43**	3.28	5.83	3.1	7.00	1911	113	37.730	-122.120	245	1962/10/3Days	3
Hayward High School	E40 3864 00	**10.59**	3.32	5.14	1.1	5.08	1956	58	37.680	-122.080	110	1962/10/3Days	3
Jenson Ranch	E40 4357 00	**11.19**	3.51	5.14	1.1	8.02	1911	84	37.718	-122.023	850	1962/10/3Days	3
Oakland 38th Ave	E40 6332 01	**14.33**	3.91	6.26	4.7	6.38	1967	31	37.760	-122.180	250	1962/10/3Days	3
Orinda Filters	E40 6501 01	**18.41**	4.88	6.51	6.5	9.04	1986	51	37.890	-122.200	370	1962/10/3Days	3

Table 2 1,000-Year Rainfalls for California (4 of 5)

12/1/95 8:12 Station	Station Number	Max Rain	Mean	Max SD	Return Period 1000 yrs	Previous Max Inches	Previous Max Year	Yrs Rec	Lat dd.ddd	Long ddd.ddd	Elev feet	Date	JDG Days
Upr San Leandro Filte	E40 9185 00	**13.14**	3.47	6.54	6.8	6.31	1982	48	37.800	-122.140	490	1962/10/3Days	3
Upper San Leandro R	E40 9185 00	**13.14**	3.49	6.49	6.4	6.31	1982	37	37.800	-122.140	490	1962/10/3Days	3
Upr San Leandro Dam	F40 9185 02	**13.67**	3.92	5.84	2.8	6.01	1956	43	37.765	-122.097	475	1962/10/3Days	3
Susanville A P	G40 8702 00	**10.12**	2.58	5.54	1.5	4.26	1956	60	40.380	-120.550	4148	1962/10/3Days	3
So Ent Yosemite	B50 8380 00	**22.99**	7.55	5.04	1.8	20.39	1956	35	37.507	-119.632	5120	1963/01/30-02/0	3
Florence Lake	B70 3093 00	**14.50**	3.76	7.04	33.0	12.20	1956	66	37.273	-118.974	7350	1963/01/30-02/0	3
Tollhouse	B70 8951 00	**8.21**	2.71	5.00	1.7	4.41	1960	46	37.017	-119.400	1790	1963/01/30-02/0	3
Lake Kittredge	E60 4686 00	**20.34**	6.27	5.27	1.2	17.50	1962	77	37.183	-122.017	1400	1963/01/30-02/0	3
Seven Mile Res	E60 8107 00	**11.62**	3.61	5.21	1.1	7.32	1980	78	37.253	-121.953	322	1963/01/30-02/0	3
Lake Spaulding	A60 4713 00	**32.60**	11.41	4.76	1.4	32.33	1986	91	39.319	-120.637	5156	1964/12/6Days	6
Soda Springs	A60 8332 00	24.50	8.84	4.54	1.0	24.95	1956	91	39.326	-121.367	6885	1964/12/6Days	6
Mt Hebron R S	F10 5941 00	**6.15**	2.08	5.54	7.6	4.58	1963	30	41.783	-122.000	4520	1964/12/6Days	6
Callahan R S	F20 1316 00	**11.23**	4.22	4.71	1.8	8.68	1956	38	41.300	-122.800	3136	1964/12/6Days	6
Gazelle	F20 3363 05	**8.09**	2.16	7.78	360.0	3.52	1982	18	41.575	-122.543	2690	1964/12/6Days	6
Yreka	F20 9866 00	**9.60**	3.37	5.24	4.5	7.26	1951	78	41.717	-122.633	2631	1964/12/6Days	6
Laytonville	F60 4851 00	**29.53**	10.95	4.81	2.0	21.18	1956	22	39.700	-123.483	1640	1964/12/6Days	6
Hockett Meadows	C20 4012 00	**30.60**	8.53	5.38	1.4	19.20	1980	24	36.367	-118.650	8500	1966/12/3-7	5
Milo 3 NE	C30 5669 00	**22.96**	6.46	5.31	1.4	13.57	1963	27	36.278	-118.711	3400	1966/12/3-7	5
Isabella Dam	C50 4303 00	**11.22**	2.74	6.43	5.9	5.65	1978	40	35.646	-118.479	2660	1966/12/3-7	5
Johnsondale	C50 4389 00	**30.45**	6.65	7.44	20.0	15.76	1963	21	35.970	-118.540	4680	1966/12/3-7	5
Kern Intake 3 SCE	C50 4519 00	**23.57**	4.45	8.93	130.0	9.67	1963	51	35.945	-118.476	3642	1966/12/3-7	5
Wofford Heights	C50 9754 00	**10.96**	2.73	6.27	4.7	5.93	1980	78	35.717	-118.450	2700	1966/12/3-7	5
Alabama Hills	W03 0050 51	**6.42**	1.36	5.88	2.3	3.88	1963	64	36.671	-118.094	3725	1966/12/3-7	5
Cottonwood Gates	W03 2071 00	**9.32**	2.09	5.46	1.3	6.70	1943	65	36.419	-118.037	3775	1966/12/3-7	5
Independence	W03 4232 00	**9.90**	1.71	7.57	17.0	4.10	1951	92	36.801	-118.185	3850	1966/12/3-7	5
White Mtn 2	W03 9632 00	**19.55**	3.97	6.20	3.4	10.60	1979	24	37.583	-118.233	12470	1966/12/3-7	5
White Mtn 1	W05 9632 00	**16.96**	3.27	6.61	5.6	5.11	1956	21	37.500	-118.183	10150	1966/12/3-7	5
Harrison Gulch	A30 3791 00	**12.60**	3.30	8.01	130.0	82.00	1982	45	40.367	-122.967	2710	1970/12/03	1
Brawley 2 SW	X23 1048 00	3.73	0.89	5.46	1.1	3.90	1933	65	32.954	-115.558	-100	1977/08/16	1
Yuma Citrus Station	X27 9890 52	**4.29**	1.01	5.56	1.2	3.51	1989	72	32.617	-114.650	190	1977/08/16	1
Yuma Valley AZ	X27 9890 80	**6.45**	0.88	10.84	600.0	1.73	1989	56	32.717	-114.717	120	1977/08/16	1
Bakersfield AP R	C00 0442 00	**3.02**	0.91	5.49	2.0	1.51	1940	53	35.427	-119.043	494	1978/02/10	1
Blackwells Corner 2W	C00 0895 00	**3.90**	0.95	7.29	24.0	1.57	1987	25	35.621	-119.894	710	1978/02/10	1
Buena Vista ARA R	C00 1171 50	**3.00**	0.96	5.01	1.1	2.10	1988	20	35.235	-119.287	340	1978/02/10	1
Buena Vista S24	C00 1174 00	**3.48**	0.93	6.44	7.9	2.43	1988	77	35.350	-119.317	310	1978/02/10	1
Buttonwillow	C00 1244 00	**3.41**	0.82	7.41	28.0	1.56	1988	53	35.400	-119.467	268	1978/02/10	1
Gin Yard	C00 3428 01	**3.56**	0.98	6.18	5.7	1.95	1979	29	35.153	-119.236	295	1978/02/10	1
Lost Hills R	C00 5151 00	**3.11**	0.97	5.18	1.3	2.01	1977	51	35.617	-119.765	285	1978/02/10	1
Lost Hills DWR	C00 5151 30	**3.19**	0.90	5.97	4.4	2.41	1991	36	35.614	-119.694	312	1978/02/10	1
North Belridge	C00 6230 50	**3.15**	1.00	5.05	1.1	1.33	1980	29	35.551	-119.791	630	1978/02/10	1
South Belridge	C00 8375 00	**3.58**	0.91	6.89	13.0	1.56	1963	49	35.455	-119.709	575	1978/02/10	1
US Cottonfield	C00 9145 00	**2.90**	0.89	5.30	1.4	1.56	1926	46	35.533	-119.276	367	1978/02/10	1
Maricopa	C70 5338 00	**4.15**	1.03	7.11	18.0	2.46	1962	72	35.080	-119.383	680	1978/02/10	1
Maricopa FS	C70 5338 01	**4.30**	1.13	6.59	9.4	2.95	1962	31	35.067	-119.400	885	1978/02/10	1
Mc Kittrick FS	C70 5480 01	**3.34**	1.03	5.26	1.5	2.33	1962	35	35.306	-119.622	1051	1978/02/10	1
Taft R	C70 8752 00	**3.90**	1.01	6.72	11.0	2.75	1962	48	35.142	-119.465	1025	1978/02/10	1

1,000-Year Rainfalls for California (5 of 5)

Table 2

12/1/95 8:12 Station	Station Number	Max Rain	Mean	Max SD	Return Period 1000 yrs	Previous Max Inches	Previous Max Year	Yrs Rec	Lat dd.ddd	Long ddd.ddd	Elev feet	Date	JDG Days
Taft KTRB	C70 8755 00	3.75	0.94	7.02	16.0	2.25	1962	34	35.147	-119.472	1030	1978/02/10	1
Ferguson Ranch	A00 3020 00	12.00	2.95	8.72	380.0	6.30	1980	25	40.350	-122.450	800	1980/12/03	1
Point Reyes Light	E10 7027 00	5.96	1.73	6.05	4.8	2.90	1900	37	38.183	-122.850	490	1982/01/04	1
Mill Valley	E20 5647 00	9.26	3.08	4.97	1.0	6.70	1979	35	37.900	-122.520	10	1982/01/04	1
Vallejo 4 N	E30 9218 50	6.05	1.84	5.66	2.8	2.30	1986	18	38.150	-121.250	23	1982/01/04	1
Berkeley	E40 0993 00	6.98	2.29	5.07	1.1	4.16	1891	107	37.867	-122.250	299	1982/01/04	1
Richmond City Hall	E40 7414 50	7.54	2.17	6.13	5.4	3.21	1978	43	37.933	-122.350	55	1982/01/04	1
San Francisco AP	E70 7769 00	5.59	1.85	5.00	1.1	4.07	1967	56	37.617	-122.383	8	1982/01/04	1
Dry Canyon Res	U03 2516 00	17.14	4.30	5.49	3.1	9.34	1926	61	34.482	-118.523	1511	1983/02/25-2	6
Black Butte Ranch	A00 0841 00	43.07	19.20	4.01	2.3	38.32	1958	35	39.788	-122.303	375	1983 Water Yea	365
Mather AFB	A00 5403 00	40.23	18.57	3.76	1.3	46.00	1969	48	38.567	-121.300	90	1983 Water Yea	365
Tisdale Weir	A00 8933 01	38.09	17.82	3.67	1.0	27.53	1982	35	39.022	-121.820	40	1983 Water Yea	365
Williams	A00 9677 00	31.94	14.52	3.87	1.7	32.55	1941	100	39.150	-122.150	90	1983 Water Yea	365
Woodland 1 WNW	A00 9781 00	38.42	17.60	3.82	1.5	33.41	1941	108	38.683	-121.800	69	1983 Water Yea	365
East Park Res	A30 2640 00	40.78	18.75	3.79	1.4	42.40	1941	79	39.367	-122.517	1205	1983 Water Yea	365
Harrison Gulch R S	A30 3791 00	81.40	37.20	3.83	1.5	59.05	1958	39	40.367	-122.967	2710	1983 Water Yea	365
Stony Gorge Res	A30 8587 00	41.61	19.34	3.71	1.1	45.33	1941	63	39.583	-122.533	770	1983 Water Yea	365
Kekseyville 2N	A80 4491 01	70.12	25.35	5.70	160.0	40.61	1941	36	38.976	-122.831	1385	1983 Water Yea	365
Upper Lake 7 W	A80 9167 00	81.76	31.32	5.20	45.0	72.15	1941	41	38.167	-122.917	1347	1983 Water Yea	365
Denair 3 NNE	B00 2389 00	25.55	11.46	3.98	2.2	22.15	1969	80	37.567	-120.783	137	1983 Water Yea	365
Lockeford	B00 5010 00	35.59	16.37	3.80	1.5	28.55	1958	54	38.163	-121.149	106	1983 Water Yea	365
Madera	B00 5233 00	22.03	10.28	3.70	1.1	20.34	1969	81	36.969	-120.069	268	1983 Water Yea	365
Manteca	B00 5303 00	27.09	11.70	4.26	4.5	19.71	1958	41	37.800	-121.200	40	1983 Water Yea	365
Modesto	B00 5738 00	26.61	11.71	4.12	3.2	22.83	1958	100	37.650	-121.000	91	1983 Water Yea	365
Modesto 6 SW	B00 5738 35	26.74	12.08	3.93	1.8	20.17	1973	19	37.625	-121.067	91	1983 Water Yea	365
Oakdale	B00 6303 00	32.06	14.83	3.76	1.3	25.76	1958	100	37.767	-120.850	188	1983 Water Yea	365
Ripon	B00 7447 80	28.24	13.09	3.75	1.2	22.21	1982	24	37.743	-121.123	65	1983 Water Yea	365
San Andreas 2 S	B20 7702 00	56.10	26.22	3.69	1.1	42.17	1956	51	38.193	-120.681	1120	1983 Water Yea	365
Big Creek # 8	B70 0755 00	60.14	27.41	3.86	1.7	51.95	1969	53	37.200	-119.333	2260	1983 Water Yea	365
Florence Lake	B70 3093 00	49.20	23.02	3.68	1.1	48.17	1969	65	37.273	-118.974	7345	1983 Water Yea	365
Huntington Lake	B70 4176 00	83.30	34.76	4.52	8.4	72.81	1969	69	37.229	-119.229	7020	1983 Water Yea	365
Antioch PP	B80 0232 00	27.09	12.55	3.75	1.2	21.68	1958	90	37.984	-121.728	60	1983 Water Yea	365
Castle Rock Rad Lab	B80 1583 00	22.79	10.10	4.07	2.8	16.63	1958	33	37.633	-121.533	625	1983 Water Yea	365
Del Puerto Road Cam	B80 2369 00	30.83	14.14	3.82	1.6	23.93	1969	20	37.423	-121.378	1125	1983 Water Yea	365
Los Banos Arbura	B80 5119 00	18.36	8.47	3.78	1.3	15.21	1958	40	36.881	-120.940	860	1983 Water Yea	365
Castle Rock	B90 1583 00	22.79	10.30	3.92	1.8	16.02	1973	31	37.633	-121.533	625	1983 Water Yea	365
Tracy Carbona	B90 8999 00	21.29	9.75	3.83	1.6	16.37	1958	52	37.696	-121.414	137	1983 Water Yea	365
Tracy Pumping Plant	B90 9001 00	25.94	11.96	3.78	1.3	21.47	1982	32	37.796	-121.581	61	1983 Water Yea	365
Sonoma St Hosp	E20 8351 03	117.03	44.64	4.83	10.0	78.63	1982	32	38.350	-122.517	440	1983 Water Yea	365
Gerber Ranch	E50 3387 00	42.58	18.34	3.93	1.4	32.15	1982	74	37.367	-121.486	2140	1983 Water Yea	365
Livermore	E50 4997 00	33.98	14.73	3.89	1.2	29.86	1890	109	37.683	-121.767	490	1983 Water Yea	365
Patterson Pass	E50 4997 40	30.60	13.12	3.97	1.5	22.20	1982	22	37.746	-121.683	685	1983 Water Yea	365
Pleasanton	E50 6991 09	46.04	19.18	4.17	2.3	30.05	1915	75	37.662	-121.897	449	1983 Water Yea	365
Campbell Water Co.	E60 1377 00	38.26	15.55	4.35	3.1	28.80	1941	75	37.288	-121.959	192	1983 Water Yea	365
Valley Christian Scho	E60 9228 03	96.70	41.23	4.00	1.6	75.10	1982	29	37.241	-122.068	1490	1983 Water Yea	365
Greenview	F20 3614 00	43.38	20.45	4.17	6.0	37.40	1974	36	41.550	-122.900	2818	1983 Water Yea	365

Table 3 Regional Coefficients of Variation

Region\Days	1	2	3	4	5	6	8	10	15	20	30	60	365
A	0.352	0.387	0.397	0.401	0.395	0.390	0.387	0.386	0.382	0.387	0.379	0.374	0.310
B	0.354	0.382	0.406	0.401	0.391	0.396	0.388	0.382	0.383	0.385	0.378	0.377	0.309
C	0.426	0.467	0.482	0.481	0.481	0.474	0.474	0.462	0.462	0.449	0.432	0.445	0.338
D	0.413	0.436	0.439	0.428	0.428	0.418	0.419	0.415	0.417	0.411	0.410	0.421	0.370
E	0.404	0.431	0.426	0.424	0.414	0.414	0.404	0.398	0.395	0.390	0.386	0.385	0.336
F	0.353	0.373	0.367	0.364	0.359	0.353	0.343	0.342	0.344	0.341	0.336	0.338	0.269
G	0.349	0.497	0.528	0.522	0.523	0.522	0.516	0.506	0.484	0.489	0.450	0.419	0.419
T	0.429	0.463	0.485	0.491	0.503	0.512	0.532	0.516	0.512	0.510	0.498	0.503	0.431
U	0.489	0.520	0.538	0.542	0.541	0.544	0.551	0.544	0.538	0.527	0.513	0.517	0.439
W	0.584	0.611	0.633	0.633	0.633	0.633	0.634	0.626	0.617	0.616	0.588	0.592	0.497
X	0.628	0.639	0.639	0.644	0.635	0.631	0.635	0.637	0.637	0.629	0.649	0.619	0.546
Y	0.466	0.492	0.510	0.508	0.501	0.497	0.494	0.485	0.486	0.479	0.465	0.502	0.413
Z	0.473	0.488	0.498	0.497	0.488	0.482	0.483	0.474	0.476	0.462	0.458	0.473	0.409

Table 4 Frequency Factors for Pearson Type III Distribution

RP\Skew	0.0	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
2	0.000	-0.050	-0.067	-0.083	-0.099	-0.116	-0.132	-0.148	-0.164	-0.180	-0.195	-0.210	-0.225	-0.240	-0.250
5	0.842	0.824	0.816	0.808	0.799	0.790	0.780	0.769	0.758	0.745	0.733	0.719	0.705	0.690	0.675
10	1.282	1.309	1.317	1.323	1.329	1.333	1.336	1.339	1.340	1.341	1.340	1.339	1.337	1.333	1.329
20	1.645	1.726	1.750	1.774	1.797	1.819	1.839	1.859	1.877	1.894	1.910	1.920	1.938	1.950	1.960
25	1.751	1.859	1.880	1.910	1.939	1.967	1.993	2.018	2.043	2.066	2.088	2.108	2.128	2.146	2.163
40	1.960	2.098	2.142	2.185	2.227	2.268	2.308	2.346	2.384	2.420	2.455	2.489	2.521	2.552	2.582
50	2.054	2.211	2.261	2.311	2.359	2.407	2.453	2.498	2.542	2.585	2.626	2.667	2.706	2.743	2.780
100	2.326	2.544	2.615	2.686	2.755	2.824	2.891	2.967	3.023	3.087	3.149	3.211	3.271	3.330	3.388
200	2.576	2.856	2.949	3.041	3.132	3.223	3.312	3.401	3.489	3.575	3.661	3.745	3.828	3.910	3.990
500	2.907	3.270	3.391	3.499	3.631	3.756	3.887	4.012	4.058	4.217	4.298	4.417	4.535	4.651	4.766
1000	3.090	3.521	3.666	3.811	3.956	4.100	4.244	4.388	4.531	4.673	4.815	4.955	5.095	5.234	5.371
2000	3.291	3.788	3.956	4.124	4.293	4.460	4.631	4.799	4.967	5.134	5.301	5.670	5.633	5.797	5.960
10000	3.719	4.374	4.597	4.821	5.047	5.274	5.501	5.729	5.957	6.185	6.412	6.640	6.870	7.093	7.318

Rainfall Depth-Duration Frequency for Arcade-Greiner

Table 5

2/8/96	DWR # A00 0249 34	Ob Time 1700	Elevation 70 Feet
19:28:30	Analysis By Jim Goodridge 916 345 3106		Latitude 38.628°
	Data from DWR, Edward C. Greiner,3435 E Country Club Lane, Sac 95821		Longitude -121.384°

Maximum Rainfall For Indicated Number Of Concecutive Days

	1	2	3	4	5	6	8	10	15	20	30	60	W-YR
1969	2.00	3.40	4.00	4.10	4.10	4.50	6.30	6.30	8.80	9.60	11.15	18.50	24.45
1970	2.08	2.47	3.00	3.39	3.64	3.64	5.38	5.77	7.09	7.67	7.74	10.93	11.59
1971	2.38	3.80	4.35	4.48	5.45	5.47	6.59	7.79	7.96	7.99	9.12	11.03	16.61
1972	1.40	2.18	2.74	3.74	3.79	4.83	4.95	4.95	4.95	5.24	5.71	6.74	11.67
1973	1.69	2.38	3.28	3.46	4.16	4.16	4.16	5.66	7.64	7.98	9.58	15.67	26.62
1974	1.46	1.91	2.24	2.92	3.00	3.07	3.71	4.21	6.33	6.33	8.33	11.45	24.92
1975	1.36	2.04	2.04	2.22	2.87	3.32	3.77	4.19	6.06	6.45	6.55	10.69	19.32
1976	1.13	1.13	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.97	2.23	3.45	9.28
1977	2.25	2.25	2.25	2.25	2.28	2.28	2.28	2.28	2.48	2.48	2.48	3.51	8.37
1978	2.40	3.50	4.35	4.98	5.36	5.59	6.17	6.67	9.08	9.93	12.18	18.21	29.25
1979	1.56	2.99	3.59	4.19	4.39	4.39	4.68	4.96	5.50	6.08	6.08	12.11	20.14
1980	1.85	2.49	3.71	4.40	5.57	6.24	7.59	7.74	8.32	9.31	10.55	16.45	28.01
1981	1.88	2.38	3.00	3.13	3.82	4.32	4.94	4.94	5.02	5.02	5.47	7.80	15.48
1982	2.65	4.44	4.96	5.01	5.77	5.77	5.77	7.22	8.17	8.61	8.90	15.17	35.31
1983	2.29	3.43	3.74	3.82	3.82	4.10	4.37	4.53	8.01	9.37	11.82	20.05	**43.79**
1984	1.76	3.11	3.52	3.79	3.95	3.97	4.27	5.44	5.86	6.90	7.91	13.73	19.20
1985	1.63	1.90	1.92	2.17	2.17	3.07	3.38	3.38	4.23	4.90	6.86	9.01	17.46
1986	2.43	4.54	**6.78**	**8.45**	**9.79**	**10.53**	**11.65**	**11.79**	**11.79**	**13.05**	**15.31**	**20.51**	33.46
1987	2.02	2.13	2.52	2.52	3.05	3.05	3.05	3.26	4.23	5.05	5.86	9.80	13.27
1988	1.68	2.50	2.50	2.50	2.67	2.67	2.92	3.06	3.36	3.50	4.55	8.23	15.91
1989	1.47	1.74	1.99	2.58	2.61	2.75	3.09	4.56	4.83	5.99	7.96	9.48	17.88
1990	2.09	2.79	3.33	3.35	3.69	3.78	4.07	4.43	4.52	5.25	5.78	9.16	17.26
1991	1.62	1.65	2.69	3.09	3.14	3.14	3.65	4.08	6.03	6.41	9.72	12.92	17.94
1992	2.51	2.82	3.83	4.42	4.99	5.29	5.79	6.59	7.52	7.80	9.45	11.50	19.65
1993	3.14	3.38	3.58	4.15	5.00	5.23	6.64	7.15	8.85	9.49	12.13	18.03	31.23
1994	1.14	1.86	2.12	2.30	2.30	2.30	2.30	2.30	4.56	4.56	6.14	6.68	15.15
1995	**4.50**	**4.78**	6.04	6.32	6.57	7.11	8.65	8.99	10.10	10.54	13.38	17.68	*34.16*
1996													
Average	2.01	2.74	3.32	3.67	4.05	4.30	4.87	5.32	6.40	6.94	8.26	12.17	21.38
Stdev	0.69	0.93	1.24	1.45	1.70	1.83	2.17	2.25	2.40	2.57	3.18	4.80	8.83
Rec Max	4.50	4.78	6.78	8.45	9.79	10.53	11.65	11.79	11.79	13.05	15.31	20.51	43.79
Rec Min	1.13	1.13	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.97	2.23	3.45	8.37
Z	3.51	1.92	2.63	3.24	3.59	3.72	3.59	3.15	2.21	2.27	2.25	1.83	3.38
Yrs Rec	27	27	27	27	27	27	27	27	27	27	27	27	27
Calc CV	.344	.338	.375	.394	.420	.425	.446	.423	.376	.371	.385	.394	.413
Reg CV	.352	.387	.397	.401	.395	.390	.387	.386	.382	.387	.379	.374	.310
Calc Skew	-1.7	-1.0	.1	1.0	1.3	1.4	1.1	.6	-.4	-.3	-.1	-.2	.5
Reg Skew	1.1	1.3	1.3	1.2	1.2	1.0	0.9	0.8	0.6	0.7	0.7	0.6	0.4
FIC	1.14	1.07	1.04	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
RP 2	2.15	2.69	3.16	3.45	3.78	4.02	4.59	5.05	6.16	6.63	7.89	11.72	20.94
RP 5	2.90	3.75	4.43	4.85	5.28	5.57	6.32	6.92	8.35	9.07	10.73	15.80	26.79
RP 10	3.38	4.45	5.28	5.76	6.26	6.54	7.40	8.07	9.65	10.53	12.43	18.21	30.12
RP 25	3.97	5.32	6.33	6.88	7.47	7.72	8.68	9.42	11.14	12.23	14.41	20.99	33.85
RP 50	4.38	5.96	7.10	7.69	8.34	8.56	9.58	10.36	12.16	13.41	15.79	22.90	36.37
RP 100	4.79	6.58	7.84	8.48	9.18	9.36	10.45	11.26	13.13	14.53	17.09	24.70	38.72
RP 200	5.18	7.18	8.57	9.25	10.01	10.14	11.29	12.13	14.05	15.60	18.34	26.42	40.93
RP 500	5.70	7.94	9.49	10.20	11.04	11.10	12.44	13.31	15.27	17.04	20.01	28.69	43.86
RP 1000	6.07	8.55	10.23	10.98	11.88	11.89	13.15	14.04	16.07	17.96	21.09	30.17	45.69
RP 10000	7.29	10.47	12.54	13.38	14.46	14.28	15.68	16.62	18.73	21.11	24.76	35.13	51.86

Table 6 Maximum Daily Rainfall by Month in California

Watershed	Yearly Max	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	17.60	12.70 Turntable Cr 1969/13	17.60 Four Trees 1986/17	9.16 Brush Creek 1940/	14.70 Helen Mine 1880/20	8.93 Kennet 1915/10	5.83 Forni Ridge 1982/18	5.96 Whiskeytown 1974/9	8.80 Redding 2W 1976/15	11.25 Turntable Cr 1959/19	11.82 Forbestown 1973/12	10.50 Downieville 1973/12	15.34 Lakeshore 1956/
B	10.80	10.80 SEntYosemite 1963/31	10.07 Cherry Valley 1963/1	7.50 Salt Sp PH 1928/	5.70 SEntYosemite 1958/3	4.57 Calaveras BT 1957/19	2.30 Long Barn 1945/3	3.14 Tiger Cr PH 1974/9	2.59 Kerlinger 1968/22	5.57 Cherry Valley 1959/19	5.14 Summerdale 1900/3	9.41 Wawona 1950/3	9.72 SEntYosemite 1955/23
C	17.00	11.15 Giant Forest 1943/21	11.30 Hockett Mdw 1982/21	7.76 Camp Wishon 1943/8	4.89 Giant Forest 1958/3	6.32 Giant Forest 1957/19	3.04 Giant Forest 1929/15	2.00 Tehachapi 1913/21	2.03 Tehachapi 1931/12	5.25 Glennville 1976/30	3.70 Visalia 1974/27	13.16 Giant Forest 1950/16	17.00 Hockett Mea 1966/6
D	15.20	15.20 Ben Lomond 1982/4	11.76 Ben Lomond 1945/1	7.04 Ben Lomond 1904/	5.75 Ben Lomond 1941/4	4.47 Ben Lomond 1957/18	2.89 Ben Lomond 1899/	2.51 Santa Cruz 1974/9	1.42 Big Sur 1976/19	11.86 Boulder Creek 1959/18	14.11 Boulder Creek 1962/12	11.94 Freedom 1950/	12.01 Los Gatos 4W 1955/23
E	15.28	11.56 Kentfield 1967/21	15.28 Atlas Road 1986/17	10.45 Lagunitas L 1879/4	14.70 Mt. St. Helena 1884/20	4.16 Pilarcitos 1957/	2.65 Pilarcitos 1884/	2.45 Kentfield 1974/8	4.28 St Helena 4 SW 1944/20	8.75 Wrights 1918/11	13.79 Wrights 1962/12	9.31 Pilarcitos 1974/	13.63 San Andreas L 1871/19
F	24.23	24.23 Bear Basin 1980/11	18.60 Bear Basin 1982/2	13.60 Ship Mtn 1985/26	6.90 Upper Mattole 1963/12	5.97 Fort Dick 1936/	4.87 Crescent City 1920/7	5.72 Crescent City 1947/26	5.95 Shelter Cove A 1983/30	7.35 Cazadero 1959/18	11.50 Orick 1950/15	10.55 Honeydew 1971/09	15.00 Ettersberg 2SE 1964/21
G	8.76	6.78 Meyers 4W 1963/	8.76 DL Bliss SP 1963/1	6.00 Boca 1907/20	4.15 Truckee 1945/13	2.61 Milford 1949/13	4.50 Meyers 4W 1963/17	3.51 Squaw Valley 1974/9	2.78 Boca 1961/8	2.60 Woodfords 1959/18	4.70 Susanville 1962/13	4.70 Markleyville 1950/17	7.60 Meyers 4W 1964/
T	16.00	16.00 Juncal Dam 1978/10	11.94 Juncal Dam 1969/25	10.50 Lewis Rch 1983/1	4.88 Juncal Dam 1958/3	4.13 Santa Margarita 1906/	1.73 Santa Maria 1933/4	1.30 Santa Ynez 1950/9	1.50 Morrow Bay 1976/	6.16 Pinecrest 1904/21	2.97 San Luis Obispo 1926/25	6.52 Gibraltar 1966/7	10.45 York Winery 1966/6
U	26.12	26.12 Hoegees 1943/23	20.00 Colbys 1944/23	15.96 Opids Camp 1937/2	12.74 Haines Cyn L 1944/4	5.69 Mt Wilson 1921/21	2.08 Acton 1925/29	1.15 Kingston 1927/26	3.46 Chatsworth 1977/17	9.02 Mt. Wilson 1939/25	6.75 Avalon 1941/22	6.96 Hogees 1966/7	15.46 Edison Intake 1921/20
W	17.61	16.81 Squirrel Inn 1916/17	14.00 East Pine Flat 1944/	17.61 L Arrowhead 1938/2	9.05 Squirrel Inn 1926/05	4.05 Squirrel Inn 1921/21	3.10 Squirrel Inn 1925/3	8.25 Chiatovich Fl 1955/19	5.02 Wildrose RS 1984/15	8.00 Squirrel Inn 1938/25	7.35 East Pine Flat 1934/18	9.94 C Independence 1970/	14.11 Sky Forest Neff 1966/6
X	13.50	11.50 Raywood 1943/	13.50 Raywood 1938/2	13.50 Raywood 1938/2	7.50 Raywood 1926/5	4.37 Raywood 1977/	1.90 Amos 1925/30	5.66 Mitchell Caverns 1984/27	5.34 Haystack 1983/17	6.52 Raywood 1976/	3.00 Raywood 1987/	9.50 Snow Cr Upper 1965/23	11.60 Raywood 1921/18
Y	24.92	24.92 Lytle Creek 1969/25	16.10 Big Bear L Dam 1891/	15.06 Big Bear L Dam 1938/2	6.50 Lytle Creek 1935/8	5.70 Big Bear L Dam 1891/	1.63 Seven Oaks 1932/3	3.90 Seven Oaks 1946/19	6.45 Yuma Valley AZ 1977/16	12.10 Fallvale 1976/10	6.37 Lytle Creek 1934/	12.40 Big Bear L Dam 1965/23	15.15 Mt Baldy Notch 1965/29
Z	14.48	11.24 Nellie 1916/17	14.48 Henshaw 1927/16	8.85 Nellie 1906/23	5.33 Cuyamaca 1926/	3.69 Palomar 1977/9	2.25 Cuyamaca 1899/1	7.10 Campo 1922/18	11.50 Campo 1891/12	5.00 Palomar 1926/11	7.58 Encinitas 1889/12	9.60 Cuyamaca 1965/23	10.40 Henshaw Dam 1965/29
Max	26.12	26.12	20.00	17.61	14.70	8.93	5.83	8.25	11.50	12.10	14.11	13.16	17.00

15-Inch-Per-Day Rainfalls for California

Table 7

Station	DWR Sta #	Lat	Long	Feet	Year	Mo	Day	Max	Rank	County	Avg Inches	Z	RP Years
Campo	Z11 1424 00	32.620	-116.470	2630	1891	8	12	16.10	25	San Diego	2.20	13.36	1M
Big Bear Lake Dam	Y01 0742 00	34.230	-116.970	6897	1891	2	22	16.20	24	San Bernardino	5.19	4.55	770
Big Bear Lake Dam	Y01 0742 00	34.230	-116.970	6897	1891	2	23	16.00	28	San Bernardino	5.19	4.47	720
Squirrel Inn 1	W28 8476 00	34.230	-117.240	5239	1916	1	17	16.81	22	San Bernardino	5.23	3.79	220
Edison Intake 75	U05 2681 30	34.211	-117.858	1275	1921	12	20	15.46	32	Los Angeles	4.50	4.98	1,000
Lake Arrowhead	W28 4671 00	34.250	-117.183	5000	1938	3	2	17.91	13	San Bernardino	5.35	4.02	240
Kelleys Camp	Y014481 20	34.233	-117.600	8300	1938	3	2	17.55	18	Los Angeles	7.34	2.98	79
Opids Camp 57	U05 6465 00	34.260	-118.090	4250	1938	3	2	15.96	30	Los Angeles	6.32	3.12	90
Big Bear Lake Dam	Y01 0742 00	34.230	-116.970	6897	1938	3	2	15.06	40	San Bernardino	5.19	4.08	410
Hoegees 60	U05 4017 00	34.210	-118.030	2650	1943	1	22	26.12	1	Los Angeles	6.09	6.73	11,000
Cogswell Dam	U05 1883 00	34.240	-117.960	2330	1943	1	22	23.12	3	Los Angeles	6.86	4.85	910
Opids Camp 57	U05 6465 00	34.260	-118.090	4250	1943	1	22	22.32	4	Los Angeles	6.32	5.18	1,300
Glenn Ranch	Y01 3461 00	34.250	-117.480	3248	1943	1	22	20.90	6	San Bernardino			
Colbys 53	U05 1896 00	34.300	-118.110	3675	1943	1	22	20.21	7	Los Angeles	4.94	6.32	6,900
Crystal Lake	U05 2198 00	34.320	-117.840	5370	1943	1	22	18.64	9	Los Angeles	5.55	4.82	880
Haines Canyon Upper	U05 3704 00	34.270	-118.250	3450	1943	1	22	18.57	11	Los Angeles	4.68	6.07	4,800
Clear Creek School 47	U05 1798 11	34.280	-118.170	3200	1943	1	22	17.87	14	Los Angeles	4.97	5.31	1,700
San Gabriel Dam 425	U05 7779 00	34.200	-117.870	1481	1943	1	22	17.81	15	Los Angeles	4.59	5.89	3,900
Mt Baldy 85	Y01 5900 00	34.240	-117.660	4275	1943	1	22	17.25	19	Los Angeles	5.45	4.65	860
Mt Wilson 338	U05 6006 00	34.230	-118.070	5709	1943	1	22	16.83	21	Los Angeles	5.09	4.72	800
Mt Wilson A S	U05 6006 00	34.220	-118.070	5709	1943	1	22	16.10	26	Los Angeles	5.09	4.42	570
Valley Forge 53	U05 9231 20	34.253	-118.072	3450	1943	1	22	16.10	27	Los Angeles	5.75	3.68	200
Monrovia Falls 150	U05 5781 05	34.180	-117.990	1800	1943	1	22	15.33	35	Los Angeles	5.62	3.53	150
Camp Baldy	Y01 1370 10	34.260	-117.670	4527	1943	1	23	19.25	8	Los Angeles	4.54	6.95	44,000
Sawpit Hogback 69	U05 8032 11	34.181	-117.972	1775	1943	1	23	18.07	12	Los Angeles	4.38	6.39	13,000
San Gabriel Dam 425	U05 7779 00	34.200	-117.870	1481	1943	1	23	17.81	16	Los Angeles	4.59	5.89	3,900
East Pine Flat	U05 2643 00	34.330	-117.840	5740	1943	1	23	15.86	31	Los Angeles			
Bennett Ranch	Y01 0678 00	34.130	-117.470	1750	1943	1	23	15.30	36	San Bernardino			
Lakeshore	A20 4709 00	40.880	-122.380	1075	1955	12	20	15.34	34	Shasta	5.87	4.58	870
Ettersberg 2 SE	F70 2906 00	40.130	-124.000	680	1964	12	21	15.00	41	Humboldt			
Mt Baldy Notch	Y01 5901 00	34.270	-117.670	7735	1965	12	29	15.15	39	San Bernardino	5.24	4.06	400
Hockett Meadows	C20 4012 00	36.370	-118.650	8500	1966	12	6	17.00	20	Tulare	4.57	6.38	7,400
Lytle Creek P H	Y01 5215 00	34.200	-117.450	2225	1969			24.92	2	San Bernardino	4.74	9.14	.44M
Lytle Creek R S	Y01 5218 00	34.230	-117.480	2760	1969	1	25	21.61	5	San Bernardino	5.60	6.14	7,200
Juncal Dam	T14 4422 00	34.480	-119.520	2060	1969	1	25	16.00	29	Santa Barbara	4.71	5.59	2,500
Opids Camp 57	U05 6465 00	34.260	-118.090	4250	1969	1	25	15.36	33	Los Angeles	6.32	2.93	73
Bear Basin	F00 0562 50	41.800	-123.740	450	1980	1	11	16.80	23	Del Norte	10.79	1.58	13
Ben Lomond Landfill	D00 0674 50	37.090	-122.070	435	1982	1	4	15.20	38	Santa Cruz	5.58	4.17	470
Bear Basin	F00 0562 50	41.800	-123.740	450	1982	2	14	18.60	10	Del Norte	10.79	2.05	26
Four Trees	A50	39.820	-121.320	5150	1986	2	17	17.60	17	Plumas			
Atlas Road Dutra	E30 0372 00	38.433	-122.250	1660	1986	2	17	15.28	37	Napa	3.96	7.08	17,000
Max		41.800	-116.470	8500				26.12			10.79	13.36	1.4M
Min		32.620	-124.000	435				15.00			2.20	1.58	13
Avg		35.239	-118.639	3790				17.67		1995/12/01	5.53	5.12	3,952
Count		41	41	42				41		3:57:26 PM	36	36	35

Max = Rainfall in inches per day, Rank = Ranking of 10 inch rainfall 1 = largest event, Avg = average maximum annual rainfall
Z = Maximum rainfall in units of standard deviations above the mean, RP = Return Period of Maximum daily Rainfall.

Table 8 Regional Coefficients of Skew

Region\Days	1	2	3	4	5	6	8	10	15	20	30	60	365
A	1.1	1.3	1.3	1.2	1.2	1.0	0.9	0.8	0.6	0.7	0.7	0.6	0.4
B	1.1	1.1	1.1	1.0	0.8	0.8	0.8	0.8	0.6	0.8	0.7	0.7	0.4
C	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.2	1.3	1.0
D	1.2	1.3	1.3	1.1	1.1	0.9	0.9	0.8	0.7	0.7	0.6	0.7	0.7
E	1.3	1.4	1.4	1.3	1.2	1.2	1.2	1.0	0.8	0.8	0.9	0.6	0.5
F	1.0	1.1	1.0	1.0	1.0	0.9	0.8	0.7	0.6	0.7	0.7	0.6	0.3
G	1.3	1.4	1.5	1.4	1.5	1.6	1.4	1.4	1.2	1.3	1.1	0.9	0.6
T	1.3	1.4	1.3	1.2	1.2	1.3	1.5	1.4	1.3	1.4	1.4	1.4	0.1
U	1.3	1.4	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.1	1.0
W	1.5	1.5	1.5	1.4	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.1
X	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.5	1.3	1.0
Y	1.2	1.3	1.3	1.2	1.2	1.2	1.1	1.0	1.0	1.0	1.0	1.4	1.0
Z	1.6	1.5	1.5	1.5	1.4	1.3	1.3	1.2	1.1	1.0	1.0	1.0	1.1

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